

**TEARDOWN REPORT  
OF TWO MODEL TPE331-10T-515K TURBOPROP ENGINES  
SERIAL NUMBER P-79297C AND P-79001C**

**October 8, 2014**

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Approved By:

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Jim Allen,  
Product Integrity



**REPORT NO.:**

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Revision	By	Approved	Date	Pages and/or Paragraphs Affected
New	JA	See Title Page	10/08/2014	All (Initial Issue)

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## **1. INTRODUCTION AND SUMMARY**

### **1.1 PURPOSE**

This report, prepared by Honeywell Aerospace, presents the findings of a tear down and examination conducted on two Honeywell Model TPE331-10T-515K turboprop engines, Serial Numbers P-79297C and P-79001C. The inspection took place at the Honeywell Investigation Laboratory in Phoenix, Arizona, between November 12 and November 14, 2013.

The inspection was conducted at the request of and under the cognizance of the National Transportation Safety Board (NTSB).

### **1.2 BACKGROUND**

On August 9, 2013, about 1121 eastern daylight time, a Rockwell International 690B, N13622, was destroyed after impacting two homes while maneuvering for landing in East Haven, Connecticut. The airplane was registered to Ellumax, LLC, and was operated by a private individual. The commercial pilot, one passenger, and two people on the ground were fatally injured. The personal flight was conducted under the provisions of 14 Code of Federal Regulations Part 91. Instrument meteorological conditions prevailed and an instrument flight rules (IFR) flight plan was filed for the flight that departed Teterboro Airport (TEB), Teterboro, New Jersey, about 1049 and was destined for Tweed-New Haven Airport (HVN), New Haven, Connecticut.

Review of preliminary data from the Federal Aviation Administration revealed that at 1115:10, the flight was cleared for the instrument landing system (ILS) approach to runway 2, circle to land runway 20 at HVN by New York Approach Control (N90). At 1115:43 the pilot contacted HVN tower and reported 7 and one half miles from SALLT intersection. The HVN local controller instructed the pilot to enter a left downwind for runway 20. At 1119:26 the pilot reported to HVN air traffic control (ATC) that he was entering a left downwind for runway 20. HVN ATC cleared the pilot to land on runway 20. While circling to runway 20, the HVN tower controller asked the pilot if he would be able to maintain visual contact with the airport. The pilot replied "622 is in visual contact now". At 1120:55 the HVN air traffic controller made a truncated transmission with the call sign "622". No further communications were received from the accident airplane. The last recorded radar target was at 1120:53, about .7 miles north of the runway 20 threshold indicating an altitude of 800 feet mean seal level.

According to a student pilot witness, who was traveling on interstate 95 (I-95) at exit 51; he looked to his right while traveling east bound and saw the airplane at the end of a right roll. The airplane was inverted and traveling at a high rate of speed, nose first, towards the ground in the vicinity of where HVN was located. He stated that he stopped at a local business and found out that the airplane had crashed.

According to another witness, who lives two houses from the impact point of the airplane, he was in his living room when he saw the airplane descending about 90 degrees right side down into the homes.

The airplane was located inverted, with the forward half of the airplane inside the basement of the primary home on a heading of 192 degrees magnetic. The cockpit, left engine and forward two-thirds of the fuselage were located inside the basement. The left wing was located on the back porch of the primary home. The right wing impacted a secondary adjacent house on the north side of the primary home. The

right engine and propeller impacted the ground in between both homes. A postaccident fire ensued and consumed a majority of the wreckage.

The recorded weather at HVN, at 1126, included wind from 170 degrees at 12 knots, gusting to 19 knots, visibility 9 miles, and overcast ceiling at 900 feet.<sup>1</sup>

### **1.3 SUMMARY**

The teardown and examination of the left engine, S/N P-79297C, revealed that the type and degree of damage was indicative of an engine that was rotating and operating at the time of impact. No pre-existing condition was found that would have prevented normal operation.

The teardown and examination of the right engine, S/N P-79001C, revealed that the type and degree of damage was indicative of an engine that was rotating and operating at the time of impact. No pre-existing condition was found that would have prevented normal operation.

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<sup>1</sup> Downloaded from [http://www.nts.gov/aviationquery/brief.aspx?ev\\_id=20130809X23530&key=1](http://www.nts.gov/aviationquery/brief.aspx?ev_id=20130809X23530&key=1) on 11-12, 2013

## 2. FINDINGS OF TPE331-10T-515K, TURBOPROP ENGINE, SERIAL NUMBER P-79297C

### NOTE

All references to position are aft looking forward unless otherwise noted.

All observations reported herein are based on visual examinations with the unaided eye, unless otherwise noted.

### 2.1 GENERAL

- a) The engine was received in a standard shipping container. (Figure 1 and Figure 2)
- b) The engine data plate identified the engine as a Model Number TPE331-10T-515K, Serial Number P-79297C, Part Number 3108120-1. (Figure 3)
- c) The following aircraft components remained attached to the engine:
  - Various wiring
  - Upper gearcase aircraft mount
  - Various engine interface control cables.
- d) The engine was generally intact. (Figure 4, Figure 5, Figure 6, and Figure 7)
- e) The engine displayed evidence of impact damage. An approximately 3 inch by 3 inch hole was noted in the upper right side of the nose cone housing. (Figure 8)
- f) Rotation of the engine's rotating group did not produce a corresponding rotation of the propeller shaft.
- g) The engine propeller shaft would not rotate.
- h) The engine's rotating group rotated with some resistance.
- i) There was earthen and white debris and in the air inlet area. (Figure 9)
- j) The oil flow metal (beta) tube was fractured and bent. The aft portion remained in the propeller shaft. (Figure 10)
- k) Portions of the aircraft mount remained attached to the rear engine mount and top gearcase mount.
- l) All engine mounts were: top, fwd (Figure 11), right (Figure 12), left (Figure 13), top, aft (Figure 14)
  - a. Intact (top, forward and aft)
  - b. Threaded inserts were missing (left and right).
- m) The starter/generator was not returned with the engine however the fractured input shaft remained within the splines of the drive gear. (Figure 15)
- n) The fuel control/fuel pump assembly was separated from the engine mount location, however, it was still attached via fuel lines and control cables. (Figure 16)
- o) Fuel pump mount flange was separated from the fuel pump.
- p) Fuel pump mount flange remained attached to the engine case. (Figure 17)
- q) Upon disassembly it was noted that most of the oil wetted components in the reduction gearbox displayed some degree of corrosion.

### 2.2 OUTPUT GEARBOX (NOSE CONE) ASSEMBLY

- (a) Nose Cone Housing:
  - The nose cone assembly was cracked in multiple locations. (Figure 18 and Figure 19)
  - There was black debris, consistent with fire soot, and earthen debris adhering to the external surfaces of the nose cone assembly. (Figure 20)
  - There was light grey debris, and earthen debris adhering to the internal surfaces of the nose cone assembly. (Figure 21)

- (b) Propeller Shaft Mount Flange:
  - The propeller shaft mounting flange appeared to be intact.
- (c) Propeller Shaft Mount Flange Alignment Dowels: (Figure 22)
  - The propeller shaft mounting flange alignment dowels appeared to be intact.
- (d) Forward Propeller Shaft Bearing Mount Bolts: (Figure 23)
  - All of the forward propeller shaft bearing mount bolts were loose and 6 were separated from the bearing housing.
  - The nuts from the forward propeller shaft bearing mount bolts had been displaced aft.
- (e) Propeller Shaft:
  - The propeller shaft displayed rotational scoring through 360 degrees immediately aft of the propeller shaft nut with corresponding rotational score marks on the sun gear forward inner bore. (Figure 24)
  - The propeller shaft displayed rotational scoring through approximately 360 degrees on the aft taper, with corresponding rotational score marks on the sun gear aft inner bore. (Figure 25)
- (f) Propeller Shaft Lock Nut: (Figure 26)
  - The propeller shaft lock nut appeared to be intact but was not removed from the shaft.
- (g) Propeller Shaft Output Seal Retainer:
  - The propeller shaft output seal retainer was not accessed during the examination.
- (h) The Propeller Shaft Bearing Oil Jet: (Figure 27)
  - The propeller shaft bearing oil jet was intact, but was displaced aft.
  - During removal of the planetary gears, the oil jet was fractured and separated.
- (i) Propeller Shaft Air/Oil Seal:
  - The carbon element of the propeller shaft air/oil seal was not accessed during the examination.
- (j) Propeller Shaft Bearing:
  - The propeller shaft bearing was not disassembled but rotated with resistance.
- (k) Propeller Shaft coupler: (Figure 28 and Figure 29)
  - The propeller shaft coupler was fractured axially and deformed radially outward. Witness marks were noted on the outer diameter of the propeller shaft coupler corresponding to forced contact with the forward inner diameter splines of the planetary gear carrier.
  - The fracture of the coupler is consistent with impact damage and was not submitted for material analysis. The propeller shaft coupler was not removed from the nose cone assembly for detailed examination.

## 2.3 INTERMEDIATE HOUSING AND GEAR (DIAPHRAGM) ASSEMBLY

- (a) Planetary Gear Assembly: (Figure 30 and Figure 31)
  - The planetary gear assembly was intact.
  - All of the planetary gear assembly gears/bearings rotated with resistance.
  - All of the planetary gears exhibited rotational scoring to the aft face (Figure 32) with corresponding score marks on the ring gear support (bumper plate).
  - All of the planetary gear teeth were intact.
  - The planetary gear assembly was not disassembled for a detailed inspection.
- (b) Ring Gear: (Figure 33)
  - The ring gear was intact.
- (c) Ring Gear Support:
  - The ring gear support was intact.
  - The ring gear support (bumper plate) displayed rotational scoring to the forward face. (Figure 34) with corresponding score marks on the aft face of all of the planet gears.
- (d) Ring Gear Retainers:
  - The ring gear retainers were in place and appeared to be undamaged but were not removed for a detailed examination.
- (e) Diaphragm Housing Assembly: (Figure 35 and Figure 36)
  - All gears and bearings of the diaphragm housing were intact. All gears were free to rotate.
  - The diaphragm housing mount flange was fractured from the housing from the 2 to 9 o'clock position. (Figure 37)
  - The diaphragm housing was not disassembled for a detailed inspection.
  - The ring gear and ring gear support were not removed from the diaphragm housing for detailed inspection.
- (f) Bull Gear (Figure 38):
  - The bull gear was free to rotate.
  - The bull gear appeared to be intact but was not removed from the diaphragm assembly.
- (g) Forward Bull Gear Bearing: (Figure 39)
  - The forward bull gear bearing appeared to be intact, but was not removed from the diaphragm assembly.
- (h) Aft Bull-Gear Bearing:
  - The aft bull-gear bearing liner was displaced aft in the diaphragm housing. (Figure 40)
  - The aft bull-gear bearing liner displayed an impact mark (Figure 41), with a corresponding impact mark on the feather valve oil transfer tube boss.
  - The aft bull-gear bearing appeared to be intact but was not removed from the diaphragm assembly.
- (i) Sun Gear:
  - The sun gear appeared to be intact, but was not removed from the diaphragm assembly. (Figure 42)
  - The sun gear displayed rotational scoring on the forward, inner bore leading edge (Figure 43) with corresponding score marks on the propeller shaft immediately behind the nut.
  - The sun gear displayed rotational scoring on the aft inner bore (Figure 44), with corresponding rotational score marks on the aft taper of the propeller shaft.

- The sun gear was gouged on the aft gear teeth. (Figure 45)
  - The bull/sun gear nut displayed rotational scoring (Figure 46) with corresponding rotational scoring to the torque sensor housing.
- (j) High-Speed Pinion (HSP): (Figure 47)
- The HSP was intact and free to rotate.
  - The HSP appeared to be undamaged, but was not removed from the diaphragm assembly for a detailed inspection.
- (k) Forward High-Speed Pinion Bearing:
- The forward high-speed pinion bearing was not accessed during the examination.
- (l) Aft High-Speed Pinion Bearing:
- The aft high-speed pinion bearing was not accessed during the examination.
- (m) HSP-to-Power Section Coupling Shaft: (Figure 48)
- The HSP-to-power section coupling shaft was intact and appeared to be undamaged, but was not removed from the high-speed pinion.
- (n) Shouldered Ball-Lock Shaft:
- The shouldered ball-lock shaft was not accessed during the examination.
- (o) Negative Torque Sensor (NTS) Quill Shaft:
- The NTS quill shaft was not accessed during the examination.
- (p) Hydraulic Pump Drive Gearshaft Assembly: (Figure 49)
- The hydraulic pump drive gearshaft assembly was intact , but was not fully accessed in the examination.
  - The hydraulic pump drive gearshaft was free to rotate.
- (q) Propeller Governor Drive Gear Assembly: (Figure 50)
- The propeller governor drive gear assembly was intact , but was not fully accessed in the examination.
  - The propeller governor drive bearings were free to rotate.
- (r) Starter/Generator Drive Gearshaft Assembly: (Figure 51 and Figure 52)
- The starter/generator drive gear was intact and free to rotate.
  - The starter/generator drive input splines were intact.
  - The starter/generator drive bearings were free to rotate.
  - The drive portion of the starter/generator input shaft was retained within the gear splines.
- (s) Starter/Generator Idler Gear Assembly: (Figure 53)
- The starter/generator idler gear assembly was intact.
  - The starter/generator idler gear assembly bearings were free to rotate.
  - The starter/generator idler gear assembly bearings were intact.

## 2.4 ACCESSORY DRIVE HOUSING (GEARCASE) ASSEMBLY

- (a) Exterior (non oil-wetted) Surfaces of the Gearcase Housing: (Figure 54)
- The accessory drive housing had black colored debris consistent with fire soot adhering to the external surfaces.
  - There was earthen debris adhering to the external surfaces and airflow path of the gearcase housing.



- (b) Interior (oil-wetted) of the Gearcase Housing: (Figure 55)
  - The interior of the gearcase housing displayed an impact mark on the feather valve oil transfer tube boss (Figure 56) with a corresponding witness mark on the aft bull-gear bearing outer race liner. (Figure 57)
  - The interior of the gearcase housing contained residual oil. (Figure 58)
- (c) Anti-Ice Shield: (Figure 59)
  - The anti-ice shield appeared to be undamaged except for some minor dents.
  - The anti-ice shield was intact.
  - The anti-ice shield was not removed for detailed inspection.
  - Service Bulletin TPE/TSE331-75-0004 was complied with. (Three air holes welded or riveted closed.)
- (d) Aft Propeller Shaft Aft Ball Bearing: (Figure 60)
  - The propeller shaft aft ball bearing was intact and free to rotate.
  - The propeller shaft aft ball bearing and liner were observed to be displaced aft in the gearcase during disassembly.
- (e) Aft propeller Shaft Roller Bearing: (Figure 61)
  - The propeller shaft roller bearing was not disassembled but was free to rotate.
  - The propeller shaft roller bearing was intact.
  - There was rotational scoring on the forward face of the aft prop shaft roller bearing outer race (Figure 62) with corresponding scoring marks on the face of all aft gear teeth of the sun gear.
- (f) Forward (compressor) Main-Shaft Nut: (Figure 63)
  - The forward (compressor) main-shaft nut appeared to be undamaged.
- (g) Main Shaft Gear: (Figure 64)
  - The main shaft gear appeared to be undamaged, aside from noted corrosion.
  - The main shaft gear was intact.
- (h) Compressor Bearing: (Figure 65)
  - The compressor bearing appeared to be undamaged
  - The compressor bearing was intact.
  - The compressor bearing was not disassembled.
  - The compressor bearing was free to rotate.
- (i) Compressor Air/Oil Carbon Seal: (Figure 66)
  - The compressor air/oil carbon seal carbon element appeared to be undamaged.
  - The compressor air/oil carbon seal rotor was intact, but had discoloration on the sealing surface. (Figure 67)
- (j) Fuel-Pump Drive Shaft:
  - The fuel-pump drive shaft was not returned with the engine.
- (k) Magnetic Drain Plug (chip detector): (Figure 68)
  - There were metal particles on the magnetic drain plug (chip detector).
  - The magnetic drain plug (chip detector) appeared to be undamaged
- (l) Oil Pressure Pump: (Figure 69)
  - The oil pressure pump drive would not rotate.
  - The oil pressure pump was intact.
  - The oil pressure pump was not disassembled from the gearcase.

- (m) Gearcase Oil-Scavenge Pump: (Figure 70)
  - The gearcase oil-scavenge pump drive would not rotate.
  - The gearcase oil-scavenge pump was not removed from the diaphragm assembly.
  - The gearcase oil-scavenge pump was intact.
- (n) Gearcase Oil-Scavenge Pump Driveshaft: (Figure 71)
  - The gearcase oil-scavenge pump drive shaft was fractured.
  - The gearcase oil-scavenge pump drive shaft o-ring was in place and intact.
- (o) Negative Torque Sensing (NTS) Regulator: (Figure 72)
  - The NTS regulator was not accessed.
- (p) NTS Transfer Tube and Orifice Assembly: (Figure 73)
  - The NTS transfer tube was intact.
  - The NTS transfer tube orifice was unobstructed. (Figure 74)
- (q) Feather Valve Oil Transfer Tube: (Figure 73)
  - The feather valve oil transfer tube was intact.
  - The feather valve oil transfer tube was unobstructed.
  - Both of the feather valve oil transfer tube o-rings were undamaged.
- (r) Torque Sensor Oil Screens: (Figure 75)
  - The torque sensor oil screens were intact and appeared to be undamaged.
  - The torque sensor oil screens did not contain debris upon disassembly.
- (s) Propeller Governor “Spider” Gasket: (Figure 76)
  - The propeller governor “spider” gasket was intact.
  - Gasket flashing was observed around several locations around the gasket.
- (t) “Lee” Check Valve:
  - The “Lee” check valve was not accessed.
- (u) Propeller Governor Reset Orifice: (Figure 77)
  - The propeller governor reset orifice appeared to be clear of debris, but was not removed from the check valve.

## 2.5 DIRECT DRIVE FUEL CONTROL (DDFC) GEAR TRAIN

- (a) General:
  - The Direct Drive Fuel Control Drive (DDFC) gear train provides mechanical drive to the following components:
    - Oil Scavenge Pump
    - Oil Pressure Pump
    - Engine Fuel Pumps
    - Engine Fuel Control
  - The Direct Drive Fuel Control Drive (DDFC) gear train comprises the following gears and gear/bearing assemblies.
    - Main shaft gear.
    - First DDFC Idler Gear/Bearing Assembly.
    - Second DDFC Idler Gear/Bearing Assembly.
    - Forth DDFC Idler Gear/Bearing Assembly.
    - Oil Pump Drive Gear.

- The DDFC gear train was found to be intact. See individual component descriptions below.
- (b) Torque Sensor: (Figure 78)
  - Part Number: 3101726-3
  - Series Number: 2
  - Serial Number: P-7083C
  - The torque sensor housing displayed rotational scoring on the forward housing surface (Figure 79) with corresponding rotational damage to the sun gear nut.
  - There were static impact marks on the forward surface of the torque sensor (Figure 80) indicating contact with the bull/sun gear aft bearing liner.
- (c) Helical Cam Gear: (Figure 81)
  - The helical cam gear was free to rotate.
  - The helical cam external gear teeth were intact.
  - The helical cam gear external teeth appeared to be undamaged, except for the noted corrosion.
  - The helical cam gear could not be removed from the first DDFC idler assembly in the torque sensor.
- (d) First Direct Drive Fuel-Control (DDFC) Gear Assembly (through the torque sensor housing): (Figure 82)
  - The first DDFC gear was free to rotate.
  - The first DDFC gear appeared to be undamaged, except for the noted corrosion.
- (e) Second DDFC Gear Assembly (through the torque sensor housing): (Figure 83 and Figure 84)
  - The second DDFC gear assembly was free to rotate.
  - Both gears of the second DDFC gear appeared to be undamaged, but were not disassembled from the torque sensor.
- (f) Third DDFC Gear: (Figure 85 and Figure 86)
  - The third DDFC gear was free to rotate.
  - Both gears of the third DDFC gear appeared to be undamaged, except for the noted corrosion.
  - Both gears of the third DDFC gear were intact. (Figure 87)
  - Both bearing(s) of the third DDFC gear appeared to be undamaged, except for the noted corrosion, but were not removed for detailed inspection.
- (g) Fourth DDFC, Tach/Generator Drive Gear, and Shaft Assembly: (Figure 88)
  - The fourth DDFC gear was intact.
  - The fourth DDFC gear appeared to be undamaged, except for the noted corrosion, but was not disassembled for detailed inspection.
  - The fourth DDFC gear rotated with resistance.
  - The tach drive gear was intact.
  - The tach drive gear appeared to be undamaged, except for the noted corrosion, but was not disassembled for detailed inspection.
  - The tach drive gear was free to rotate.

## 2.6 COMPRESSOR SECTION

- (a) Shouldered Main Shaft: (Figure 89 and Figure 90)
  - The shouldered (main) shaft appeared to be undamaged.

- (b) Torsion Shaft: (Figure 91 and Figure 92)
- The torsion shaft was separated just forward of the aft splines. The torsion shaft was not submitted for material analysis. However, the characteristics of the fracture surfaces were typical of a torsional overload separation.
- (c) First-Stage Compressor Impeller Shroud: (Figure 93 and Figure 94)
- The first-stage compressor impeller shroud displayed a shroud rub through approximately 360 degrees at the exducer and inducer area(s) (Figure 95) with corresponding rotational scoring on the impeller shroud line edge.
- (d) First-Stage Compressor Impeller: (Figure 96 and Figure 97)
- Part Number: 3108182-2
  - Serial Number: 97035-0105765
  - Lot Number: 99-P121
  - As viewed through the gearcase air inlet, the first-stage compressor impeller had several non-adjacent blades bent in the opposite direction of rotation at the leading edge outer diameter (Figure 98).
  - There was earthen debris adhering to the first-stage compressor impeller blades and flow path surfaces.
  - The first-stage compressor impeller blades displayed rotational scoring on the shroud line edge (Figure 99) with corresponding rotational scoring on the first-stage compressor impeller shroud.
  - The first-stage compressor impeller blades had the leading-edges bent opposite to the direction of rotation on 5 blades.
  - The first-stage compressor impeller blades had the leading edge of all blades damaged (rough / pitted) due to foreign object damage. (Figure 100)
  - The first-stage compressor impeller displayed rotational scoring through approximately 360 degrees on the aft hub (Figure 101) consistent with knife seal witness marks from the crossover duct.
- (e) First-stage Compressor Diffuser (crossover duct): (Figure 102 and Figure 103)
- The first-stage compressor diffuser was intact.
  - The first-stage compressor diffuser displayed damage consistent with foreign object damage to the leading edges of most of the vanes. (Figure 104)
  - The first-stage compressor diffuser contained earthen debris and wooden material compacted between the diffuser vanes. (Figure 105)
- (f) Second-Stage Compressor Housing: (Figure 106 and Figure 107)
- The second-stage compressor housing was intact.
  - The second-stage compressor housing was covered with earthen debris on the external surfaces.
  - The second-stage compressor housing contained debris adhering to the flow path surfaces of the transition area. (Figure 108)
  - The second-stage compressor housing displayed rotational scoring in the inducer area corresponding to scoring on the second stage impeller blade shroud line surfaces. (Figure 109)
- (g) Second-Stage Compressor Impeller: (Figure 110 and Figure 111)
- Part Number: 893482-5
  - Serial Number: 0-03501-3781
  - Lot Number: 1814
  - The second-stage compressor impeller forward curvic coupling teeth appeared to be undamaged. (Figure 112)

- The second-stage compressor impeller aft curvic coupling teeth appeared to be undamaged. (Figure 113)
  - The second-stage compressor impeller displayed earthen debris adhering to the blades and flow path surfaces. (Figure 114)
  - The second-stage compressor impeller blades displayed rotational scoring on the shroud line edge (Figure 115) with corresponding rotational scoring on the second-stage compressor impeller shroud.
- (h) Second-Stage Compressor Diffuser Vane Assembly: (Figure 116 and Figure 117)
- The second-stage compressor diffuser vane assembly was intact.
  - The second-stage compressor diffuser vane assembly appeared to be undamaged.
  - The second-stage compressor diffuser vane assembly contained what appeared to be building insulation debris between the diffuser vanes. (Figure 118)

## 2.7 COMBUSTION SECTION

- (a) General:
- All fuel nozzles were in place and their bolts were installed and safety wire was intact.
  - The plenum, combustor and fuel manifolds were removed as one assembly.
  - There was earthen debris found in various cooling holes, fuel nozzle swirlers, inner diameter seams and skirts of the combustor as well as the inner wall of the plenum.
- (b) Combustor Plenum Case: (Figure 119 and Figure 120)
- There was earthen debris adhering to the external surface of the combustor plenum case. (Figure 121)
  - The combustor plenum case was dented and punctured at approximately the 3 o'clock position. (Figure 122)
- (c) De-swirl Vane Assembly:
- The de-swirl vane assembly was intact.
  - The de-swirl vane assembly had earthen debris adhering to the leading edges of many of the vanes. (Figure 123)
- (d) Combustion Chamber:
- The combustion chamber was intact
  - The combustion chamber contained earthen debris in and around various cooling holes, fuel nozzle swirlers, inner diameter seams and skirts of the combustor. (Figure 124, Figure 125, Figure 126)
  - The combustion chamber was not removed from the plenum for detailed inspection.
- (e) Outer Transition Liner: (Figure 127 and Figure 128)
- The outer transition liner was intact.
  - There was earthen debris in the dished area of the outer transition liner.

## 2.8 TURBINE SECTION

- (a) Center Curvic Coupling: (Figure 129)
- The center curvic coupling was intact.
  - The center curvic forward coupling teeth appeared to be undamaged. (Figure 130)
  - The center curvic aft coupling teeth appeared to be undamaged. (Figure 131)
- (b) First-Stage Turbine Stator Assembly: (Figure 132 and Figure 133)
- The first-stage turbine stator assembly was not disassembled from the vane case.
  - There was dirt adhering to all of the vane surfaces of the first-stage turbine stator. (Figure 134)

- There was earthen debris located in and around the inner transition liner (including in the cooling holes) of the first-stage turbine stator. (Figure 135 and Figure 136)
  - The first-stage turbine stator displayed rotational scoring through approximately 90 degrees of the shroud surface. (Figure 137)
- (c) First-Stage Turbine Rotor: (Figure 138 and Figure 139)
- Part Number: 3101520-3
  - Serial Number: 98032-2900372
  - Lot Number: LN99-P112
  - There were white colored deposits and earthen debris on the pressure side and leading edge of the first-stage turbine rotor blades. (Figure 140)
  - There were rotational score marks at the leading edge tip of all the first-stage rotor turbine blades. (Figure 141)
  - There was earthen debris on the suction side of the first-stage turbine rotor blades. (Figure 142)
  - The first-stage turbine rotor forward and aft curvic teeth appeared to be undamaged.
  - After cleaning, the first-stage turbine rotor displayed metal spray deposits on the suction side turbine blades. (Figure 143 and Figure 144)
- (d) Second-Stage Turbine Stator: (Figure 145 and Figure 146)
- The second-stage turbine stator was intact.
  - After cleaning, the second-stage turbine stator displayed metal spray deposits on the suction side of the stator vanes. (Figure 147)
  - The second-stage turbine stator displayed rotational scoring through approximately 90 degrees of the shroud surface (Figure 148) with corresponding scoring to the shroud line edge of all second-stage turbine blades.
- (e) Second-Stage Turbine Rotor: (Figure 149 and Figure 150)
- Part Number: 3102106-10
  - Serial Number: 98013-4516790
  - Lot Number: 99-P036
  - The second-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 151) with corresponding rotational scoring on the second-stage turbine blade tip shroud.
  - There were compressor-shroud metal spray deposits on the suction side of the second-stage turbine rotor blades. (Figure 152 and Figure 153)
  - The second-stage turbine rotor forward and aft curvic teeth appeared to be undamaged.
- (f) Third-Stage Turbine Stator: (Figure 154, and Figure 155)
- The third-stage turbine stator was intact.
  - There was dirt adhering to both the pressure leading edge surfaces of the third-stage turbine stator vanes. (Figure 156)
  - The third-stage turbine blade tip shroud displayed rotational scoring through 90 degrees (Figure 157) with corresponding scoring on the shroud line edge of the third-stage turbine rotor blades.
  - After cleaning, the third-stage turbine stator displayed metal-spray deposits on the suction side of the third-stage turbine stator vanes. (Figure 158)
- (g) Third-Stage Turbine Rotor: (Figure 159 and Figure 160)
- Part Number: 3102655-2
  - Serial Number: 98013-4507119
  - Lot Number: 98-P213

- The third-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 161) with corresponding rotational scoring on the third-stage turbine blade tip shroud.
  - After cleaning, the third-stage rotor displayed compressor-shroud metal-spray deposits on the suction side of the turbine blades. (Figure 162)
  - The forward and aft curvic teeth of the third-stage turbine rotor appeared to be undamaged.
- (h) Rear Curvic Coupling:
- The rear curvic coupling appeared to be undamaged. (Figure 163 and Figure 164)
  - The rear curvic coupling teeth appeared to be undamaged.
- (i) Engine Exhaust Duct: (Figure 165)
- The engine exhaust duct was intact and appeared to be undamaged.
- (j) Thermocouple Harness Assembly:
- The thermocouple harness was broken leading into one of the thermocouples at the 11 O'clock position, but otherwise appeared to be undamaged. (Figure 166)
  - The thermocouple harness assembly was not disassembled from the exhaust duct.
- (k) Turbine Bearing Support Housing: (Figure 167 and Figure 168)
- The turbine bearing support housing was intact.
  - The turbine bearing support housing appeared to be undamaged.
- (l) Turbine Oil-Scavenge Pump and Drive Shaft: (Figure 169 and Figure 170)
- The turbine oil-scavenge pump and drive shaft appeared to be undamaged except for the noted corrosion on the external surfaces of the pump housing.
  - The turbine oil-scavenge pump element drive gear appeared to be undamaged. (Figure 171)
  - The turbine oil-scavenge pump drive shaft rotated freely with corresponding free rotation of the pump element drive gear.
  - The turbine oil-scavenge pump housing contained residual oil.
  - The turbine oil-scavenge pump appeared to be undamaged.
- (m) Turbine Oil Inlet Tube and Jet: (Figure 172 and Figure 173)
- The turbine oil inlet tube and jet were intact.
  - The turbine oil inlet jet appeared to be unobstructed. (Figure 174)
- (n) Turbine Air/Oil Carbon Seal: (Figure 175)
- The turbine air/oil carbon element appeared to be undamaged.
  - The turbine air/oil carbon element supporting spring appeared to be undamaged and retained spring action/force. (Figure 176)
- (o) Turbine Bearing: (Figure 177)
- The turbine bearing was intact
  - The turbine bearing appeared to be undamaged.
- (p) Aft (Turbine) Main-Shaft Nut: (Figure 178)
- The aft (turbine) main-shaft nut was intact and appeared to be undamaged.
  - The aft (turbine) main-shaft nut was removed with standard tooling.



## 2.9 CONTROLS & ACCESSORIES

- (a) Manual Fuel Shutoff Valve: (Figure 179 and Figure 180)
  - Part Number: 394230-9-1
  - Serial Number: P-4325C
  - The solenoid cover was dented.
  - The electrical connector was damaged.
  - Exterior surfaces covered with a black, ash-like debris.
- (b) Fuel Pump Assembly: (Figure 181)
  - Part Number: PF4-057-6D
  - Serial Number: MX285857
  - The fuel pumps were not separated from the fuel control.
  - The fuel pumps were not disassembled.
  - The fuel pump drive was not free to rotate.
  - The fuel pump gearcase mount flanges were broken.
  - There was earthen debris adhering to the external surfaces of the fuel pump.
- (c) Fuel Control: (Figure 182 and Figure 183)
  - Part Number: 2549118-42
  - Serial Number: 312198
  - The external surfaces of the fuel control assembly were covered with earthen debris.
  - The fuel control assembly forward mount was fractured.
  - The fuel control assembly power lever shaft rotated freely.
  - The fuel control assembly underspeed governor input shaft rotated with resistance.
  - The fuel control assembly underspeed governor input shaft lever was bent. (Figure 184)
- (d) Fuel Filter: (Figure 185)
  - The fuel filter was not accessed during the examination.
- (e) Fuel Flow Divider: (Figure 186 and Figure 187)
  - Part Number: 394408-8-1
  - Serial Number: 1611CA
  - There was earthen debris adhering to the external surface of the fuel flow divider.
  - The fuel flow divider was damaged due to exposure to heat.
- (f) Fuel Manifold Hose Assembly: (Figure 188)
  - The fuel manifold hose assembly was not removed from the combustor plenum case.
  - The exterior surfaces of the fuel manifold hose assembly were covered with a black ash-like debris.
  - The fuel manifold hose assembly was damaged due to exposure to heat.
  - There was dirt adhering to the nozzle housing and shroud surfaces of the fuel manifold hose assembly.
  - Insulation was missing from small portions of the fuel manifold hoses.
  - The fuel manifold hose assembly was separated in two locations adjacent to two fuel nozzles. (Figure 189 and Figure 190)
- (g) Propeller Governor: (Figure 191 and Figure 192)
  - Part Number: 894418-6
  - Serial Number: 1712926 E
  - The propeller governor drive shaft and control lever were free to rotate.



- (h) Propeller Pitch Control: (Figure 193 and Figure 194)
  - Part Number: 895481-17
  - Serial Number: P-7859C
  - The propeller pitch control was not disassembled.
  - There was dirt adhering to the external surfaces of the propeller pitch control.
  - The propeller pitch control mount flange was fractured at all of mounting locations.
  - The propeller pitch control sleeve / cam were free to move.
  - The propeller pitch control sleeve guide pin was not accessed
- (i) Oil Filter: (Figure 195)
  - The oil filter was not disassembled for a detailed inspection.
  - The oil filter housing was cracked at two locations at the mounting flange.
  - The oil filter housing was dented.
- (j) Oil Tank: (Figure 196)
  - The oil tank was intact.
  - The oil tank was dented in several locations. (Figure 197)
  - The oil tank contained residual oil.
  - The exterior surfaces of the oil tank were covered with earthen debris.
- (k) Ignition Exciter: (Figure 198 and Figure 199)
  - Part Number: 10-378400-5 C
  - Serial Number: 9429R011
  - One of the ignition exciter output connectors were separated from the ignition exciter body.
  - The ignition exciter's two of the four mount lugs were broken out of the mount bracket.
  - Earthen debris was adhering to the exterior surfaces of the ignition exciter.
- (l) Exciter to Igniter Lead Assembly: (Figure 200)
  - The exciter to igniter lead assembly was impact damaged and separated at several locations
  - A portion of the exciter to igniter lead assembly was still attached to the engine's igniters.
- (m) Igniters:
  - The igniters were not removed from the plenum for detailed examination.
  - One igniter plug had been displaced inwards and was fractured at the base of the treaded portion of the igniter plug. (Figure 201)
- (n) Oil to Fuel Heater: (Figure 202)
  - The oil to fuel heater was not accessed during the examination.
  - Residual fuel was noted to be coming from the oil to fuel heater.
- (o) Anti-Ice Valve: (Figure 203)
  - Part Number: 319980-1-13
  - Serial Number: P13697
  - The anti-ice valve electrical connector was separated above the attachment point.
- (p) Feather Valve: (Figure 204)
  - The feather valve appeared to be intact, and actuated freely by hand.
  - The feather valve was not disassembled from the gearcase.
- (q) P2T2 Inlet Sensor: (Figure 205)
  - The P2T2 inlet sensor displayed signs of impact damage on the temperature sensor coils and was fractured from the gearcase.

- There was dirt adhering to the P2T2 inlet sensor coil surfaces and exterior surfaces.
- (r) Beta and Negative Torque Sensing (NTS) Switch Manifold: [\(Figure 206\)](#)
- The beta and NTS switch manifold was in place and intact.
  - The electrical connectors on the switches were damaged.
  - The exterior surfaces of the NTS switch manifold were covered with earthen debris.
- (s) Torq/Temp Limiter (TTL) By-Pass Valve: [\(Figure 207\)](#)
- Part Number: 895380-4
  - Serial Number: 89-08265-1769
  - The TTL by-pass valve was intact.
  - The TTL by-pass valve mounting bracket was separated from the engine mounts.
  - The exterior surfaces of the TTL by-pass valve were covered with earthen debris.

### 3. FINDINGS OF TPE331-10T-515K, TURBOPROP ENGINE, SERIAL NUMBER P-79001C

#### NOTE

All references to position are aft looking forward unless otherwise noted.

All observations reported herein are based on visual examinations with the unaided eye, unless otherwise noted.

#### 3.1 GENERAL

- a) The engine was received in a standard shipping container. (Figure 208 and Figure 209)
- b) The engine data plate identified the engine as a Model Number TPE331-10T-515K, Serial Number P-79001C, Part Number 3108120-1. (Figure 210)
- c) The following aircraft components remained attached to the engine:
  - Nacelle pieces
  - Various wiring
  - Upper gearcase aircraft mount
  - Aircraft rear mount.
  - Various engine interface control cables.
- d) The engine was generally intact however the Intermediate case was fractured at the mounting flange to the compressor case. (Figure 211, Figure 212 and Figure 213) Upon disassembly, it was noted that entire gearbox had heavy corrosion in the internal case surfaces and ferrous based components. Unless otherwise noted, all internal gear box components exhibited heavy corrosion.
- e) The engine displayed evidence of fire damage. (Figure 214)
- f) The engine displayed evidence of impact damage. (Figure 215)
- g) The engine propeller shaft would not rotate.
- h) The engine's rotating group would not rotate.
- i) There was earthen debris in the air inlet area. (Figure 216)
- j) The oil flow metal (beta) tube was fractured and bent. (Figure 217) The aft portion remained in the propeller shaft.
- k) Portions of the aircraft mounts remained attached to the rear engine mount and top gearcase mount.
- l) All engine mounts were: top, fwd (Figure 218), right (Figure 219), left (Figure 220), top, aft (Figure 221)
  - a. Intact (top, forward and aft)
  - b. Threaded inserts were missing (right).
  - c. Fractured (left).
- m) The starter/generator was not returned with the engine however the fractured input shaft remained within the splines of the drive gear.
- n) The fuel control/fuel pump assembly was separated from the engine mount location, however, it was still attached via fuel lines and control cables. (Figure 222)

#### 3.2 OUTPUT GEARBOX (NOSE CONE) ASSEMBLY (1591 CCW)

- (a) Nose Cone Housing:
  - The nose cone assembly was intact
  - There was earthen debris adhering to the external surfaces of the nose cone assembly. (Figure 223)
  - There was earthen debris and heavy magnesium corrosion elements adhering to the internal surfaces of the nose cone assembly. (Figure 224)

- (b) Propeller Shaft Mount Flange: (Figure 225)
  - The propeller shaft mounting flange was bent.
- (c) Propeller Shaft Mount Flange Alignment Dowels: (Figure 225)
  - The propeller shaft mounting flange alignment dowels were intact.
- (d) Forward Propeller Shaft Bearing Mount Bolts: (Figure 226)
  - 6 of the forward propeller shaft bearing mount bolts were bent and loose.
  - One of the forward propeller shaft bearing mount bolts was missing.
  - The nuts on 6 bolt shanks of the forward propeller shaft bearing mount bolts had been displaced aft and were separated from the bolts.
- (e) Propeller Shaft:
  - The nose cone assembly was not disassembled for a detailed inspection of the propeller shaft.
  - The propeller shaft displayed rotational scoring through 360 degrees immediately aft of the propeller shaft nut with corresponding rotational score marks on the sun gear forward inner bore. (Figure 227)
  - The propeller shaft displayed rotational scoring through approximately 360 degrees on the aft taper, with corresponding rotational score marks on the sun gear aft inner bore. (Figure 228)
- (f) Propeller Shaft Lock Nut: (Figure 229)
  - The propeller shaft lock nut appeared to be undamaged.
  - The propeller shaft lock nut was intact.
- (g) Propeller Shaft Output Seal Retainer:
  - The propeller shaft output seal retainer was not accessed during the examination.
- (h) The Propeller Shaft Bearing Oil Jet: (Figure 230)
  - During disassembly, the propeller shaft bearing oil jet was broken with the mount lug and bolt still attached.
- (i) Propeller Shaft Air/Oil Seal:
  - The carbon element of the propeller shaft air/oil seal was not accessed during the examination.
- (j) Propeller Shaft Bearing:
  - The propeller shaft bearing was not disassembled and did not rotate.
- (k) Propeller Shaft Coupler: (Figure 231)
  - The propeller shaft coupler was not disassembled from the nose cone, and was intact.

### 3.3 INTERMEDIATE HOUSING AND GEAR (DIAPHRAGM) ASSEMBLY

- (a) Planetary Gear Assembly: (Figure 232 and Figure 233)
  - The planetary gear assembly was intact.
  - All of the planetary gear assembly gears/bearings would not rotate.
  - All of the planetary gears exhibited rotational scoring to the aft face (Figure 234) with corresponding score marks on the ring gear support (bumper plate).
  - The planetary gears assembly was not disassembled for a detailed inspection.
- (b) Ring Gear: (Figure 235)
  - The ring gear was intact.

- (c) Ring Gear Support:
  - The ring gear support (bumper plate) displayed rotational scoring to the forward face and was fractured in two places, (Figure 236 and Figure 237) with corresponding score marks on the aft face of all of the planet gears.
  - The ring gear support (bumper plate) was fractured and displaced aft .
- (d) Ring Gear Retainers:
  - The ring gear retainers were in place and appeared to be intact but were not removed for a detailed examination.
- (e) Diaphragm Housing: (Figure 238 and Figure 239)
  - The diaphragm assembly was intact.
  - All of the gears associated with the diaphragm housing were not free to rotate.
  - The diaphragm housing mount flange was fractured at four adjacent bolts holes near the four to five o'clock position. (Figure 240)
  - The diaphragm housing was not disassembled for a detailed inspection.
- (f) Bull Gear (Figure 241):
  - The bull gear was not free to rotate.
  - The bull gear appeared to be intact but was not removed from the diaphragm assembly.
- (g) Forward Bull Gear Bearing:
  - The forward bull gear bearing appeared to be intact, but was not removed from the diaphragm assembly.
- (h) Aft Bull Gear Bearing:
  - The aft bull gear bearing and liner were displaced aft in the diaphragm housing. (Figure 242)
  - The aft bull-gear bearing appeared to be intact but was not removed from the diaphragm assembly.
- (i) Sun Gear:
  - The sun gear appeared was intact but was not removed from the diaphragm assembly. (Figure 243)
  - The sun gear displayed rotational scoring on the forward, inner bore leading edge (Figure 244) with corresponding score marks on the propeller shaft immediately behind the nut.
  - The sun gear displayed rotational scoring on the aft inner bore (Figure 245), with corresponding rotational score marks on 360 degrees on the aft taper of the propeller shaft.
  - The sun gear displayed rotational scoring on the aft gear teeth. (Figure 246)
  - The bull/sun gear nut displayed rotational scoring (Figure 247) with corresponding rotational scoring to the torque sensor housing.
- (j) High-Speed Pinion HSP: (Figure 248)
  - The HSP would not rotate.
  - The HSP was intact, but was not removed from the diaphragm assembly for a detailed inspection.
- (k) Forward High-Speed Pinion Bearing:
  - The forward high-speed pinion bearing was not accessed during the examination.
  - The forward high-speed pinion bearing was not free to rotate.
- (l) Aft High-Speed Pinion Bearing:
  - The aft high-speed pinion bearing was not accessed during the examination.

- The forward high-speed pinion bearing was not free to rotate.
- (m) HSP-to-Power Section Coupling Shaft: (Figure 249)
  - The HSP-to-power section coupling shaft was intact.
  - The HSP-to-power section coupling shaft was not removed from the high-speed pinion.
- (n) Shouldered Ball-Lock Shaft:
  - The shouldered ball-lock shaft was not accessed during the examination.
- (o) Negative torque sensor (NTS) quill shaft:
  - The NTS quill shaft was not accessed during the examination.
- (p) Hydraulic Pump Drive Gearshaft Assembly: (Figure 250)
  - The hydraulic pump drive gearshaft gear was intact.
  - The hydraulic pump drive gearshaft bearings would not rotate.
  - The hydraulic pump drive gearshaft bearings were intact.
- (q) Propeller Governor Drive Gear Assembly: (Figure 251)
  - The propeller governor drive gear was intact.
  - The propeller governor drive bearings would not rotate.
  - The propeller governor drive bearings were intact.
- (r) Starter/Generator Drive Gearshaft Assembly: (Figure 252)
  - The starter/generator drive gear was intact.
  - The starter/generator drive input splines were intact.
  - The starter/generator drive bearings would not rotate.
  - The starter/generator drive bearings were intact.
  - The drive portion of the starter/generator input shaft was retained within the gear splines.
- (s) Starter/Generator Idler Gear Assembly: (Figure 253)
  - The starter/generator idler gear assembly was intact.
  - The starter/generator idler gear assembly bearings would not rotate.
  - The starter/generator idler gear assembly bearings were intact.
- (t) Gearcase Oil-Scavenge Pump Drive Shaft: (Figure 254)
  - The gearcase oil-scavenge pump drive shaft could not be removed from the oil pump, but appeared to be intact.

### 3.4 ACCESSORY DRIVE HOUSING (GEARCASE) ASSEMBLY

- (a) Exterior (non oil-wetted) Surfaces of the Gearcase Housing: (Figure 255)
  - The exterior of the accessory drive housing displayed damaged due to impact, with fracturing of the aft bolt flange and midsection.
  - The accessory drive housing had black colored debris consistent with fire soot adhering to the external surfaces.
  - The accessory drive housing had earthen debris adhering to the external surfaces.
- (b) Interior (oil-wetted) of the Gearcase Housing: (Figure 256)
  - The gearcase housing had earthen debris and corrosion materials adhering to the internal surfaces.
- (c) Anti-Ice Shield: (Figure 257)
  - The anti-ice shield was intact, but had some minor dents and fire damage.
  - The anti-ice shield was not removed for detailed inspection.

- Service Bulletin TPE/TSE331-75-0004 was complied with. (Three air holes welded or riveted closed.)
- (d) Propeller Shaft Aft Ball Bearing: (Figure 258 and Figure 259)
  - The propeller shaft aft ball bearing was intact, but displaced aft and was separated from the gearcase upon disassembly of the propeller pitch control from the gearcase.
  - The propeller shaft aft ball bearing was not free to rotate.
- (e) Propeller Shaft Aft Roller Bearing: (Figure 260)
  - The propeller shaft roller bearing was not disassembled but rotated with some resistance.
  - The propeller shaft roller bearing outer race was fractured on the aft side through approximately 180 degrees. (Figure 261)
  - There was rotational scoring on the forward face of the aft prop shaft roller bearing outer race (Figure 262) with corresponding scoring marks on the face of the aft gear teeth of the sun gear.
- (f) Forward (Compressor) Main-Shaft Nut: (Figure 263)
  - The forward (compressor) main-shaft nut was intact and appeared to be undamaged.
- (g) Main Shaft DDFC Drive Gear: (Figure 264)
  - The main shaft gear was intact and appeared to be undamaged, aside from the noted corrosion.
- (h) Compressor Bearing: (Figure 265)
  - The compressor bearing was intact.
  - The compressor bearing was not free to rotate.
  - The compressor bearing was not removed from the compressor bearing carrier.
- (i) Compressor Air/Oil Carbon Seal: (Figure 266)
  - The compressor air/oil carbon seal was not accessed during the examination, but appeared to be intact within the bearing carrier assembly.
- (j) Fuel-Pump Drive Shaft: (Figure 267)
  - The fuel-pump drive shaft was bent, with damage to the spline teeth on the fuel pump side.
  - Only one of the fuel-pump drive shaft o-rings were in place and intact (fuel pump side).
- (k) Magnetic Drain Plug (Chip Detector): (Figure 268)
  - There was earthen and metallic debris on the magnetic drain plug (chip detector).
  - The magnetic drain plug (chip detector) appeared to be undamaged.
- (l) Oil Pressure Pump: (Figure 269)
  - The oil pressure pump drive was not free to rotate, and was not disassembled from the gearcase for detailed inspection.
  - The oil pressure pump was intact.
- (m) Gearcase Oil-Scavenge Pump: (Figure 270)
  - The gearcase oil-scavenge pump drive would not rotate, but was not removed from the diaphragm assembly for detailed inspection.
- (n) Negative Torque Sensing (NTS) Regulator: (Figure 271)
  - The NTS regulator was not accessed.
- (o) NTS Transfer Tube and Orifice Assembly: (Figure 272)
  - The NTS transfer tube was intact.

- The NTS transfer tube orifice was unobstructed. (Figure 273)
- (p) Feather Valve Oil Transfer Tube: (Figure 274)
  - The feather valve oil transfer tube was intact.
  - The feather valve oil transfer tube was unobstructed.
  - Both of the feather valve oil transfer tube o-rings were undamaged.
- (q) Feather Valve Oil Transfer Tube Mount Boss: (Figure 275)
  - There were witness marks on the feather valve oil transfer tube mount boss corresponding to contact with the aft Bull/Sun gear bearing outer sleeve.
- (r) Oil Screens (Torque Sensor): (Figure 276)
  - The torque sensor oil screens were intact and appeared to be undamaged.
  - The torque sensor oil screens did not contain debris when initially disassembled.
- (s) Propeller Governor “Spider” Gasket: (Figure 277)
  - The propeller governor “spider” gasket was intact and showed flashing around the edges.
- (t) “Lee” Check Valve:
  - The “Lee” check valve was not accessed.
- (u) Propeller Governor Reset Orifice: (Figure 278)
  - The propeller governor reset orifice appeared to be clear of debris, but was not removed from the “Lee” check valve assembly.

### 3.5 DIRECT DRIVE FUEL CONTROL (DDFC) GEAR TRAIN

- (a) General:
  - The Direct Drive Fuel Control Drive (DDFC) gear train provides mechanical drive to the following components:
    - Oil Scavenge Pump
    - Oil Pressure Pump
    - Engine Fuel Pumps
    - Engine Fuel Control
  - The Direct Drive Fuel Control Drive (DDFC) gear train comprises the following gears and gear/bearing assemblies.
    - Main shaft gear.
    - First DDFC Idler Gear/Bearing Assembly.
    - Second DDFC Idler Gear/Bearing Assembly.
    - Forth DDFC Idler Gear/Bearing Assembly.
    - Oil Pump Drive Gear.
  - The DDFC gear train was found to be intact, but was heavily corroded. See individual component descriptions below.
- (b) Torque Sensor: (Figure 279)
  - Part Number: 3101726-3
  - Series Number: 2
  - Serial Number: P-3362C
  - The torque sensor housing displayed rotational scoring on the forward housing surface (Figure 280) with corresponding rotational damage to the sun gear nut.
  - There were static impact marks on the forward surface of the torque sensor (Figure 281) indicating contact with the bull/sun gear aft bearing liner.



- (c) Helical Cam Gear: (Figure 282)
  - Prior to removal from the torque sensor housing, the helical cam gear was not free to rotate.
  - The helical cam external gear teeth were intact.
- (d) First Direct Drive Fuel-Control (DDFC) Gear Assembly (through the torque sensor housing):
  - The first DDFC gear was not free to rotate.  
The first DDFC gear appeared to be intact. (Figure 283)
- (e) Second DDFC Gear Assembly (through the torque sensor housing): (Figure 284 and Figure 285)
  - The second DDFC gear assembly was not free to rotate.
  - Both of the second DDFC gears were intact.
  - Both bearings of the second DDFC gear were intact, but were not accessed for detailed inspection.
- (f) Third DDFC Gear (double gear): (Figure 286)
  - The third DDFC gear was not free to rotate.
  - Both gears of the third DDFC gear were intact.
  - Both bearings of the third DDFC gear appeared to be intact, but were not accessed for detailed inspection.
- (g) Fourth DDFC, Tach/Generator Drive Gear, and Shaft Assembly: (Figure 287)
  - The fourth DDFC gear was intact.
  - The fourth DDFC gear was not free to rotate.
  - The tach drive gear was intact.
  - The tach drive gear was not free to rotate.
  - All of bearings of the fourth DDFC and tach/generator drive gears appeared to be intact, but were not accessed for detailed inspection.

## 3.6 COMPRESSOR SECTION

- (a) Shouldered (Main) Shaft: (Figure 288)
  - The shouldered (main) shaft displayed wear on face of the spline teeth that mate with the center curvic spline teeth. (Figure 289) The shaft otherwise appeared undamaged.
- (b) Torsion Shaft: (Figure 290)
  - The torsion shaft was separated in the area adjacent to the aft bushing. The torsion shaft was not submitted for material analysis. However, the characteristics of the fracture surfaces were typical of a torsional overload separation. (Figure 291)
- (c) First-Stage Compressor Impeller Shroud: (Figure 292 and Figure 293)
  - The first-stage compressor impeller shroud displayed a shroud rub through approximately 360 degrees at the inducer and exducer areas (Figure 294) with corresponding rotational scoring on the impeller vane shroud line edge.
  - The first-stage compressor impeller shroud had 4 mount bolt flanges broken.
- (d) First-Stage Compressor Impeller: (Figure 295 and Figure 296)
  - Part Number: 3108182-2
  - Serial Number: 98035-0102790
  - Lot Number: 99-P051
  - As viewed through the gearcase air inlet, the first-stage compressor impeller had several blades bent in the opposite direction of rotation at the leading edge outer diameter (Figure 297).

- There was earthen debris adhering to the first-stage compressor impeller vanes and flow path surfaces.
  - The first-stage compressor impeller displayed rotational scoring on the blade shroud line edge (Figure 298 and Figure 299) with corresponding rotational scoring on the first-stage compressor impeller shroud.
  - The first-stage compressor impeller had the blade leading-edges bent opposite to the direction of rotation on 2 blades. (Figure 300)
  - The first-stage compressor impeller had the blade leading edge of all blades damaged (rough / pitted).
  - The first-stage compressor impeller displayed rotational scoring through 360 degrees on the aft hub (Figure 301) with corresponding scoring on the inner diameter of the crossover duct housing seal area.
  - The first-stage compressor impeller aft curvic teeth were heavily damaged and smeared. (Figure 301)
- (e) First-Stage Compressor Diffuser (crossover duct): (Figure 302 and Figure 303)
- The first-stage compressor diffuser displayed damage consistent with foreign object damage to the leading edges of most of the vanes. (Figure 304)
  - The first-stage compressor diffuser contained earthen debris between the diffuser vanes.
  - The first-stage compressor diffuser displayed rotational scoring marks in the seal housing area (Figure 305) with corresponding witness marks on the first and second stage impeller aft and forward hubs, respectively.
  - The first-stage compressor diffuser displayed axial witness marks on all of the aft housing “ribs” (Figure 306) with corresponding witness marks to the inner diameter of the shroud support of the second stage compressor housing.
  - The first stage compressor diffuser had six of the case mounting studs fractured from the diffuser. (Figure 307)
  - The first stage compressor diffuser was fractured circumferentially around the first-stage impeller shroud mounting flange through approximately 90 degrees. (Figure 308)
- (f) Second-Stage Compressor Housing: (Figure 309 and Figure 310)
- The second-stage compressor housing was intact.
  - The second-stage compressor housing displayed compression wrinkles (axial damage). (Figure 311)
  - The second-stage compressor housing was covered with black soot debris on the external surfaces.
  - The second-stage compressor housing contained earthen debris adhering to the flow path surfaces of the transition area. (Figure 312)
  - The second-stage compressor housing displayed a shroud rub through 360 degrees (Figure 313) with corresponding rotational scoring on the second-stage compressor impeller blades.
  - There were witness marks to the inner diameter of the second-stage compressor housing shroud support (Figure 314) with corresponding axial witness marks on the aft housing “ribs” of the crossover duct.
- (g) Second-Stage Compressor Impeller: (Figure 315 and Figure 316)
- Part Number: 893482-5
  - Serial Number: 5-03501-5111
  - Lot Number: 9482
  - The shroud line edge of all second-stage compressor impeller blades displayed rotational scoring (Figure 317) with corresponding rotational scoring to the second-stage impeller shroud.
  - The leading edge of all second-stage compressor impeller blades were damaged (rough / pitted) due to foreign object damage.

- The second-stage compressor impeller forward curvic coupling teeth were heavily damaged and smeared. (Figure 318)
  - The second-stage compressor impeller aft curvic coupling teeth were heavily damaged. (Figure 319)
  - The second-stage compressor impeller displayed rotational scoring on the forward hub of the second-stage compressor impeller (Figure 318) with corresponding rotational scoring on the inner diameter of the crossover duct housing seal area.
- (h) Second-Stage Compressor Diffuser Vane Assembly:(Figure 320)
- The second-stage compressor diffuser vane assembly was intact, but was not removed from the outer transition liner.
  - The second-stage compressor diffuser vane assembly contained earthen debris between the diffuser vanes. (Figure 321)

### 3.7 COMBUSTION SECTION

- (a) General:
- The plenum, combustor and fuel manifolds were removed as one assembly.
  - There was earthen debris found in various cooling holes, fuel nozzle swirlers, inner diameter seams and skirts of the combustor as well as the inner wall of the plenum.
  - The plenum, combustor, and fuel manifolds were fire damaged.
- (b) Combustor Plenum Case: (Figure 322 and Figure 323)
- The combustor plenum case was intact.
  - There was black debris, consistent with soot, adhering to the external surface of the combustor plenum case. (Figure 324)
  - The combustor plenum case was dented and punctured at the 3 o'clock position and displayed compression wrinkles (axial damage). (Figure 325)
- (c) De-swirl Vane Assembly: (Figure 326)
- The de-swirl vane assembly was intact.
  - The de-swirl vane assembly had earthen debris adhering to the surfaces of all vanes. (Figure 327)
- (d) Combustion Chamber:
- The combustion chamber was intact, but was dented in the area adjacent to dent/puncture on the plenum. (Figure 328)
  - There was earthen debris adhering to the outer liner surfaces of the combustion chamber. (Figure 329 and Figure 330)
  - The combustion chamber was not removed from the plenum for detailed inspection.
- (e) Outer Transition Liner:
- The outer transition liner was intact.
  - There was earthen debris adhering to the inner surfaces of the outer transition liner. (Figure 331)
  - The outer transition liner displayed impact damage adjacent to the impact damage on the plenum. (Figure 332)

### 3.8 TURBINE SECTION

- (a) Center Curvic Coupling: (Figure 333)
- The center curvic coupling was intact.
  - The center curvic coupling knife seals were slightly worn.
  - The center curvic forward coupling teeth were moderately damaged. (Figure 334)
  - The center curvic aft coupling teeth appeared to be undamaged. (Figure 335)

- (b) First-Stage Turbine Stator Assembly: (Figure 336 and Figure 337)
- The first-stage turbine stator assembly was not disassembled from the vane case.
  - There was earthen debris adhering to all of the vane surfaces of the first-stage turbine.
  - There was earthen debris located in and around the inner transition liner of the first-stage turbine stator.
  - There were compressor-shroud metal spray deposits on the suction side of the first-stage turbine stator vanes. (Figure 338)
  - There was dirt located in several cooling holes of the inner transition liner of the first-stage turbine stator. (Figure 339)
  - The first-stage turbine blade tip shroud displayed rotational scoring on all segments (Figure 340) with corresponding rotational scoring to the shroud line edges of the first-stage turbine blades.
- (c) First-Stage Turbine Rotor: (Figure 341 and Figure 342)
- Part Number: 3101520-3
  - Serial Number: 98032-2900362
  - Lot Number: LN99-P112
  - The first-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 343) with corresponding rotational scoring on the first-stage turbine blade tip shroud.
  - The first-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 344) with corresponding scoring to the forward inner vane support for the second-stage stator.
  - There were compressor-shroud metal spray deposits on the suction side of the first-stage turbine rotor blades. (Figure 345)
  - The leading edge tips of the first-stage turbine rotor blades showed signs of erosion. (Figure 346)
  - The first-stage turbine rotor forward curvic teeth were slightly damaged.
  - The first-stage turbine rotor aft curvic teeth were slightly damaged.
- (d) Second-Stage Turbine Stator: (Figure 347 and Figure 348)
- The second-stage turbine stator was intact.
  - There were compressor-shroud metal spray deposits on the leading edge and outer platform of the second-stage turbine stator vanes. (Figure 349)
  - There were compressor-shroud metal spray deposits on the suction side of the second-stage turbine stator vanes. (Figure 350)
  - The second-stage turbine stator displayed rotational score marks on the forward face of the inner vane support (Figure 351) with corresponding score marks on the aft face of the first-stage turbine wheel blade platforms.
  - The second-stage turbine blade tip shroud displayed some rotational scoring. (Figure 352)
- (e) Second-Stage Turbine Rotor: (Figure 353 and Figure 354)
- Part Number: 3102106-10
  - Serial Number: 98013-4516439
  - Lot Number: 99-P2036
  - The second-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 355) with corresponding scoring to the forward inner vane support for the third-stage stator.
  - The second-stage turbine rotor displayed rotational scoring on the aft hub face (Figure 356) with corresponding scoring to the forward inner vane support for the third-stage stator.

- There were compressor-shroud metal spray deposits on the suction side of the second-stage turbine rotor blades. (Figure 357)
  - There were compressor-shroud metal spray deposits on the leading edge of the second-stage turbine rotor blades. (Figure 358)
  - The second-stage turbine rotor forward curvic teeth appeared to be undamaged.
  - The second-stage turbine rotor aft curvic teeth appeared to be undamaged.
- (f) Third-Stage Turbine Stator: (Figure 359 and Figure 360)
- The third-stage turbine stator was intact.
  - There were compressor-shroud metal spray deposits on the suction side of the third-stage turbine stator vanes. (Figure 361)
  - There were compressor-shroud metal spray deposits on the leading edge of the third-stage turbine stator vanes. (Figure 362)
  - The third-stage turbine stator displayed rotational score marks on the forward inner vane support (Figure 363) with corresponding rotational scoring to the aft blade platforms of the second-stage turbine wheel.
  - The third-stage turbine stator displayed rotational score marks on the inner diameter seal support (Figure 364) with corresponding rotational score marks on the aft balance rim of the second-stage turbine disk.
  - The third-stage turbine blade tip shroud appeared to be undamaged except for normal superficial rubbing.
- (g) Third-Stage Turbine Rotor: (Figure 365 and Figure 366)
- Part Number: 3102655-2
  - Serial Number: 98013-4503727
  - Lot Number: 98-P122
  - The third-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 367) with corresponding scoring to the forward face on the inner housing of the rear bearing support.
  - The third-stage turbine rotor had compressor-shroud metal spray deposits on the suction side of the blades. (Figure 368)
  - The forward curvic teeth of the third-stage turbine rotor appeared to be undamaged.
  - The aft curvic teeth of the third-stage turbine rotor appeared to be undamaged.
- (h) Rear Curvic Coupling: (Figure 369 and Figure 370)
- The rear curvic coupling appeared to be undamaged.
- (i) Engine Exhaust Duct: (Figure 371 and Figure 372)
- The engine exhaust duct was heavily buckled and crushed.
- (j) Thermocouple Harness Assembly:
- The thermocouple harness electrical connector was fractured from the harness and not returned with the engine.
  - The thermocouple harness assembly was impact damaged and crushed with the engine exhaust duct.
- (k) Turbine Bearing Support Housing: (Figure 373 and Figure 374)
- The turbine bearing support housing was intact.
  - The turbine bearing support housing displayed rotational scoring to the forward face on the inner housing of the rear bearing support with corresponding rotational scoring on the aft blade platforms of the third-stage turbine wheel. (Figure 375)
  - The turbine bearing support displayed compressor shroud metal spray deposits on the struts. (Figure 376)

- (l) Turbine Oil-Scavenge Pump and Drive Shaft: (Figure 377 and Figure 378)
  - The turbine oil-scavenge pump element drive gear appeared to be undamaged.
  - The turbine oil-scavenge pump drive shaft rotated freely with corresponding free rotation of the pump element drive gear.
  - The turbine oil-scavenge pump housing contained residual oil, water, and corrosion elements.
- (m) Turbine Oil Inlet Tube and Jet: (Figure 379)
  - The turbine oil inlet tube and jet were intact.
  - The turbine oil inlet jet appeared to be unobstructed.
- (n) Turbine Air/Oil Carbon Seal: (Figure 380 and Figure 381)
  - The turbine air/oil carbon element appeared to be undamaged.
  - The turbine air/oil carbon element supporting spring appeared to be undamaged and retained spring action/force.
- (o) Turbine Bearing: (Figure 382 and Figure 383)
  - The turbine bearing was intact
  - The turbine bearing appeared to be undamaged.
  - There was residual oil present.
- (p) Aft (turbine) Main-Shaft Nut: (Figure 384)
  - The aft (turbine) main-shaft nut was intact.
  - The aft (turbine) main-shaft nut was removed with standard tooling.
  - The aft (turbine) main-shaft nut appeared to be undamaged.

### 3.9 CONTROLS & ACCESSORIES

- (a) Manual Fuel Shutoff Valve: (Figure 385 and Figure 386)
  - Part Number: 394230-9-1
  - Serial Number: indiscernible, name plate was consumed in the post crash fire.
  - The manual fuel shutoff valve was heavily damaged by fire, including much of the solenoid, valve body, electrical connector, and actuator arm.
- (b) Fuel Pump Assembly: (Figure 387 and Figure 388)
  - Part Number: PF4-057-6D
  - Serial Number: MX316031
  - The fuel pumps were not separated from the fuel control during disassembly, but were fractured aft of the mounting flange in the fuel control. (Figure 389)
  - The fuel pumps were not disassembled.
  - The fuel pump drive was not free to rotate.
  - The fuel pump gearcase mount flanges were broken.
  - There was earthen debris, and black soot-like debris adhering to the external surfaces of the fuel pump.
  - The fuel pump was damaged due to exposure to heat.
- (c) Fuel Control: (Figure 390 and Figure 391)
  - Part Number: 893528-32
  - Serial Number: 335290
  - There was earthen debris, solidified previously molten aluminum, and black soot-like debris adhering to the external surfaces of the fuel control assembly.
  - The fuel control assembly was damaged due to exposure to heat.
  - The fuel control assembly forward mount was fractured.
  - The fuel control assembly drive was not free to rotate.

- The fuel control assembly housing forward of the aft cover plate was fractured, exposing internal components. (Figure 392)
  - The fuel control assembly power lever shaft would rotate with resistance.
  - The fuel control assembly underspeed governor input shaft would not rotate.
- (d) Fuel Filter: (Figure 393 and Figure 394)
- The fuel filter housing was fractured at the mount.
  - The fuel filter inlet fitting was bent.
  - The fuel filter was not accessed during the examination.
- (e) Fuel Flow Divider: (Figure 395 and Figure 396)
- Part Number: Indiscernible, nameplate consumed in the fire.
  - Serial Number: Indiscernible, nameplate consumed in the fire.
  - There was solidified molten aluminum, and black soot-like debris adhering to the external surface of the fuel flow divider.
  - The fuel flow divider was partially consumed by fire.
- (f) Fuel Manifold Hose Assembly: (Figure 397 and Figure 398)
- The fuel manifold hose assembly was heavily damaged due to exposure to fire, resulting in the complete consumption of the insulation material.
  - There was earthen debris and soot-like debris adhering to the nozzle housing and shroud surfaces of the fuel manifold hose assembly.
  - The fuel manifold hose assembly was separated in three locations, adjacent to the three of the fuel nozzles.
- (g) Propeller Governor: (Figure 399 and Figure 400)
- Part Number: 894418-6
  - Serial Number: 100865 C
  - Prior to disassembly from the gearcase, solidified molten aluminum was observed on the top the governor housing. (Figure 401)
  - The propeller governor drive shaft was free to rotate.
  - The propeller governor reset fitting was bent.
  - The propeller governor exterior surfaces were covered with black, ash-like debris.
  - The propeller governor was damaged due to exposure to heat.
- (h) Propeller Pitch Control: (Figure 402, Figure 403 and Figure 404)
- Part Number: 895481-17
  - Serial Number: P-1427C
  - The propeller pitch control was not disassembled.
  - There was earthen debris adhering to the external surfaces of the propeller pitch control.
  - The propeller pitch control mount flange was fractured at all of the mounting locations.
  - The propeller pitch control sleeve/cam were free to move.
  - The propeller pitch control exterior surfaces were covered with black, ash-like debris.
  - The propeller pitch control was damaged due to exposure to heat.
- (i) Oil Filter: (Figure 405)
- The oil filter was not disassembled for a detailed inspection, but otherwise showed no structural damage.
- (j) Oil Tank: (Figure 406 and Figure 407)
- The oil tank was partially crushed.
  - The oil tank contained residual oil.
  - The exterior surfaces of the oil tank were covered with black, ash-like debris.
  - Damaged due to exposure to heat.



- (k) Ignition Exciter: (Figure 408)
  - Part Number: Indiscernible, nameplate consumed in the fire.
  - Serial Number: Indiscernible, nameplate consumed in the fire.
  - The ignition exciter housing was partially consumed by fire exposing internal components.
  - All three electrical connectors of the ignition exciter were separated.
  - The exterior surfaces of the ignition exciter housing were covered with black, ash-like debris.
  - The ignition exciter housing was damaged due to exposure to heat.
- (l) Exciter to Igniter Lead Assembly: (Figure 409)
  - The exciter to igniter lead assemblies were impact damaged and separated from the igniters and the exciter.
  - The exciter to igniter lead assemblies were fire damaged with solidified molten aluminum adhering to the wiring and adjacent components.
- (m) Igniters: (Figure 410)
  - The igniters were not removed from the plenum for detailed examination.
  - Both ignitor plugs were attached to the plenum, however, they were separated from the ignitor leads.
- (n) Oil to Fuel Heater: (Figure 411)
  - The oil to fuel heater was not accessed during the examination.
  - Residual fuel was noted coming from the oil to fuel heater.
- (o) Anti-Ice Valve: (Figure 412)
  - Part Number: 319980-1-13
  - Serial Number: P9991
  - The anti-ice valve solenoid was partially consumed by fire.
  - The anti-ice valve exterior surfaces were covered with black, ash-like debris, including solidified molten aluminum.
- (p) Feather Valve: (Figure 413 and Figure 414)
  - The feather valve appeared to be intact.
  - The feather valve exterior surfaces were covered with black, ash-like debris and solidified molten aluminum prior to disassembly from the gearcase.
  - The feather valve was damaged due to exposure to heat.
- (q) P2T2 Inlet Sensor: (Figure 415)
  - The P2T2 inlet sensor displayed signs of impact damage on the temperature sensor coils, and was fractured from the gearcase.
  - There was earthen debris adhering to the P2T2 inlet sensor coil and external surfaces.
- (r) Beta and Negative Torque Sensing (NTS) Switch Manifold: (Figure 416)
  - The beta and NTS switch manifold was partially consumed by exposure to fire.
  - The exterior surfaces of the NTS switch manifold were covered with black, ash-like debris.
- (s) Torq/Temp Limiter (TTL) By-Pass Valve: (Figure 417)
  - Part Number: 895380-4
  - Serial Number: 7-08265-265
  - The TTL by-pass valve was impact damaged and fractured from mounting bracket.



- The TTL by-pass valve fuel inlet fitting was fractured from the housing and the exit fitting was bent.
- The electrical connector was fractured from the housing.
- The exterior surfaces of the TTL by-pass valve were covered with earthen and black, ash-like debris.

## **4. ANALYSIS AND CONCLUSIONS**

### **4.1 ANALYSIS OF TPE331-10T-515K, TURBOPROP ENGINE, SERIAL NUMBER P-79297C**

#### **Engine rotation at the time of impact was evidenced by:**

- Rotational scoring to the propeller shaft.
- Rotational scoring to the sun gear.
- Rotational scoring on the planetary gears.
- Rotational scoring on the first-stage compressor impeller shroud.
- Leading edges of several first-stage compressor impeller blades bent opposite the direction of rotation.
- Rotational scoring to the shroud line edge of all first-stage compressor impeller blades.
- Rotational scoring on the aft hub of the first-stage compressor impeller.
- Rotational scoring through 360 degrees on the air seal area of the first-stage compressor diffuser assembly.
- Rotational scoring through 360 degrees on the second-stage compressor housing impeller shroud.
- Rotational scoring on the shroud line edge of all second-stage compressor impeller blades.
- Rotational scoring on the first-stage turbine blade tip shroud.
- Rotational scoring on the shroud line edge of all the first-stage turbine rotor blade tips.
- Rotational scoring on the second-stage turbine blade tip shroud.
- Rotational scoring on the shroud line edge of all second-stage turbine rotor blade tips.
- Rotational scoring on the third-stage turbine blade tip shroud.
- Rotational scoring on the shroud line edge of all third-stage turbine rotor blade tips.
- Earthen and wooden debris was compacted in the combustor plenum case.

#### **Operation at the time of impact was evidenced by:**

- Metal spray deposits adhering to the suction side of the first-stage turbine blades.
- Metal spray deposits adhering to the suction side of the second-stage turbine stator vanes.
- Metal spray deposits adhering to the suction side of the second-stage turbine blades.
- Metal spray deposits adhering to the suction side of the third-stage turbine stator vanes.
- Metal spray deposits adhering to the suction side of the third-stage turbine blades.

### **4.2 ANALYSIS OF TPE331-10T-515K, TURBOPROP ENGINE, SERIAL NUMBER P-79001C**

#### **Engine rotation at the time of impact was evidenced by:**

- Rotational scoring to the propeller shaft.
- Rotational scoring to the sun gear.
- Rotational scoring on the planetary gears.
- Rotational scoring on the first-stage compressor impeller shroud.
- Leading edges of several first-stage compressor impeller blades bent opposite the direction of rotation.
- Rotational scoring to the shroud line edge of all first-stage compressor impeller blades.
- Rotational scoring on the aft hub and curvic of the first-stage compressor impeller.

- Rotational scoring through 360 degrees on the air seal area of the first-stage compressor diffuser assembly.
- Rotational scoring through 360 degrees on the second-stage compressor housing impeller shroud.
- Rotational scoring on the shroud line edge of all second-stage compressor impeller blades.
- Rotational scoring on the forward hub and curvic of the second-stage compressor impeller.
- Rotational scoring on the first-stage turbine blade tip shroud.
- Rotational scoring on the shroud line edge of all the first-stage turbine rotor blade tips.
- Rotational scoring on the first-stage turbine aft blade platforms with corresponding scoring to the forward inner vane support for the second-stage stator.
- Rotational scoring on the second-stage turbine blade tip shroud.
- Rotational scoring on the shroud line edge of all second-stage turbine rotor blade tips.
- Rotational scoring on the second-stage turbine aft blade platforms with corresponding scoring to the forward inner vane support for the third-stage stator.
- Rotational scoring on the second-stage turbine rotor aft hub face with corresponding scoring to the forward inner vane support for the third-stage stator.
- Rotational scoring on the third-stage turbine aft blade platforms with corresponding scoring to the forward face on the inner housing of the rear bearing support.
- Earthen debris was found in the combustor plenum case.

**Operation at the time of impact was evidenced by:**

- Metal spray deposits adhering to the suction side of the first-stage turbine blades.
- Metal spray deposits adhering to the suction side of the second-stage turbine stator vanes.
- Metal spray deposits adhering to the leading edge and suction side of the second-stage turbine blades.
- Metal spray deposits adhering to the suction side of the third-stage turbine stator vanes.
- Metal spray deposits adhering to the leading edge and suction side of the third-stage turbine blades.
- Metal spray deposits adhering to the turbine bearing support struts.

## 4.3 CONCLUSIONS

The teardown and examination of the right engine, S/N P-79297C, revealed that the type and degree of damage was indicative of an engine that was rotating and operating at the time of impact. No pre-existing condition was found that would have prevented normal operation.

The teardown and examination of the left engine, S/N P-79001C, revealed that the type and degree of damage was indicative of an engine that was rotating and operating at the time of impact. No pre-existing condition was found that would have prevented normal operation.

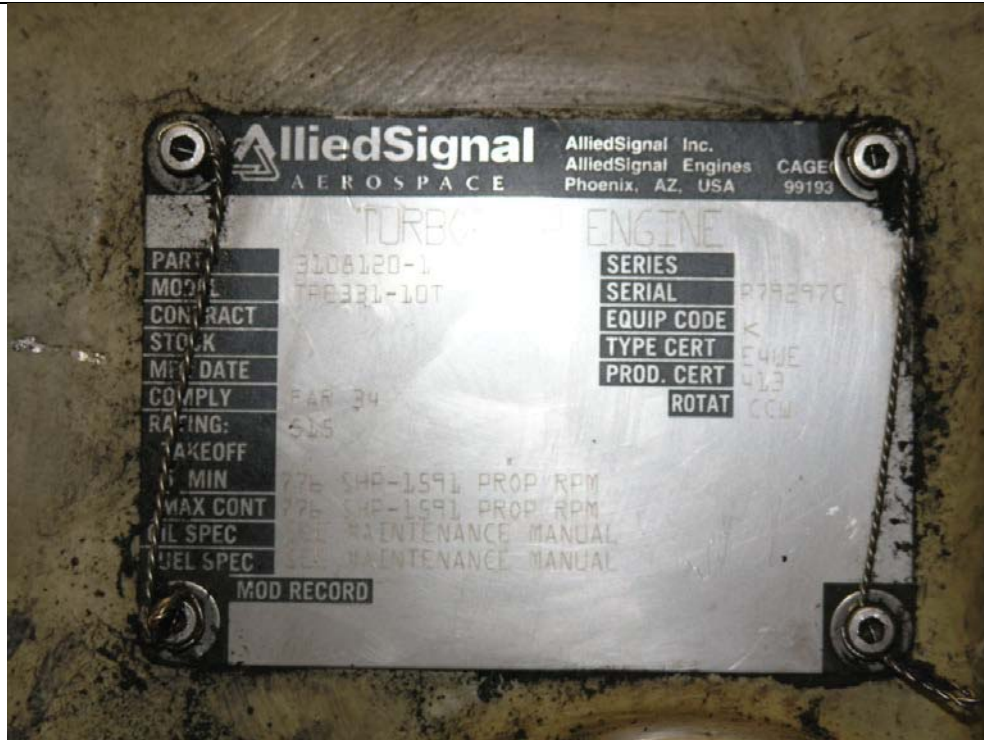


**Figure 1. P-79297C, As-Received**



**Figure 2. P-79297C, As-Received**





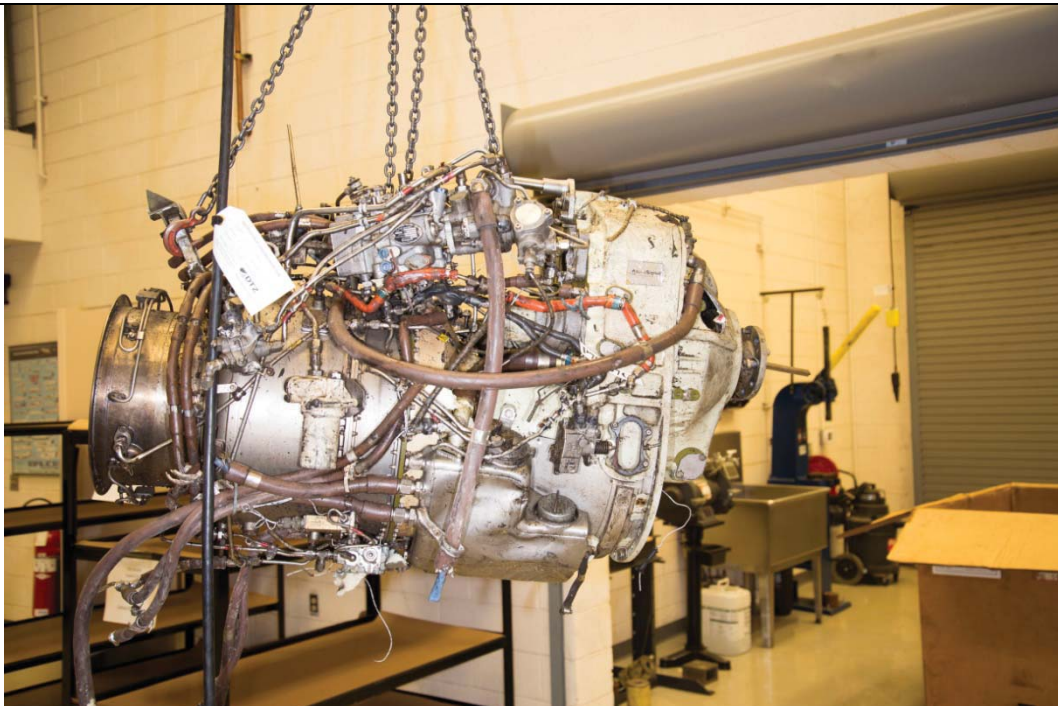
**Figure 3. P-79297C, Dataplate**



**Figure 4. P-79297C, Gearcase and Propeller Section, FLA**

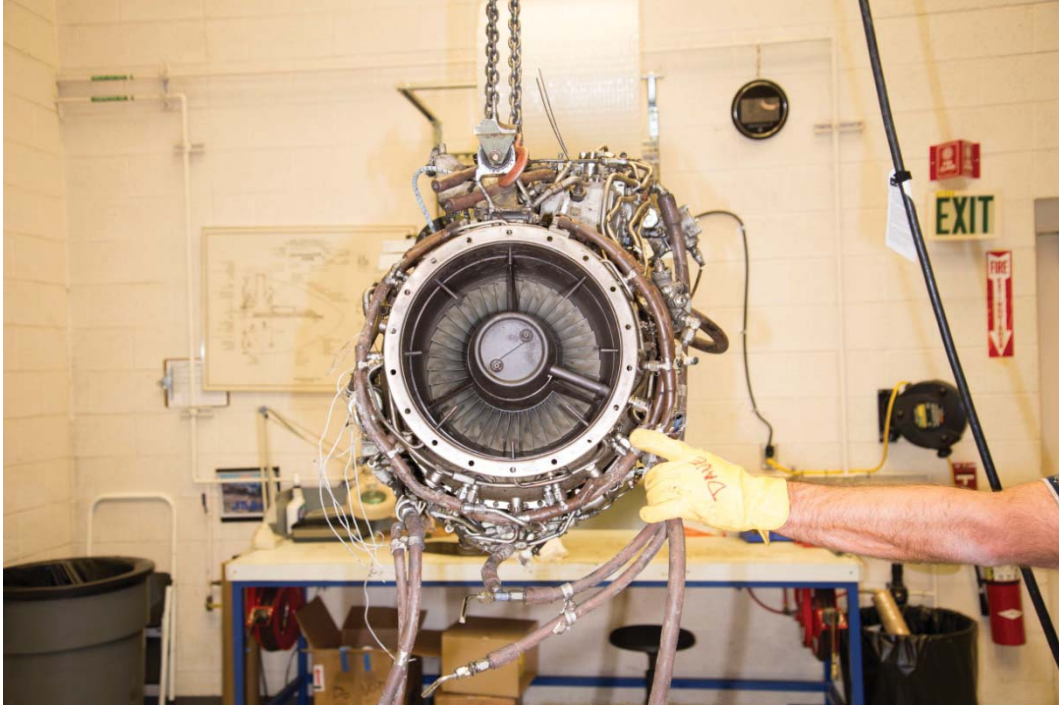


**Figure 5. P-79297C, Left Side**



**Figure 6. P-79297C, Right Side**

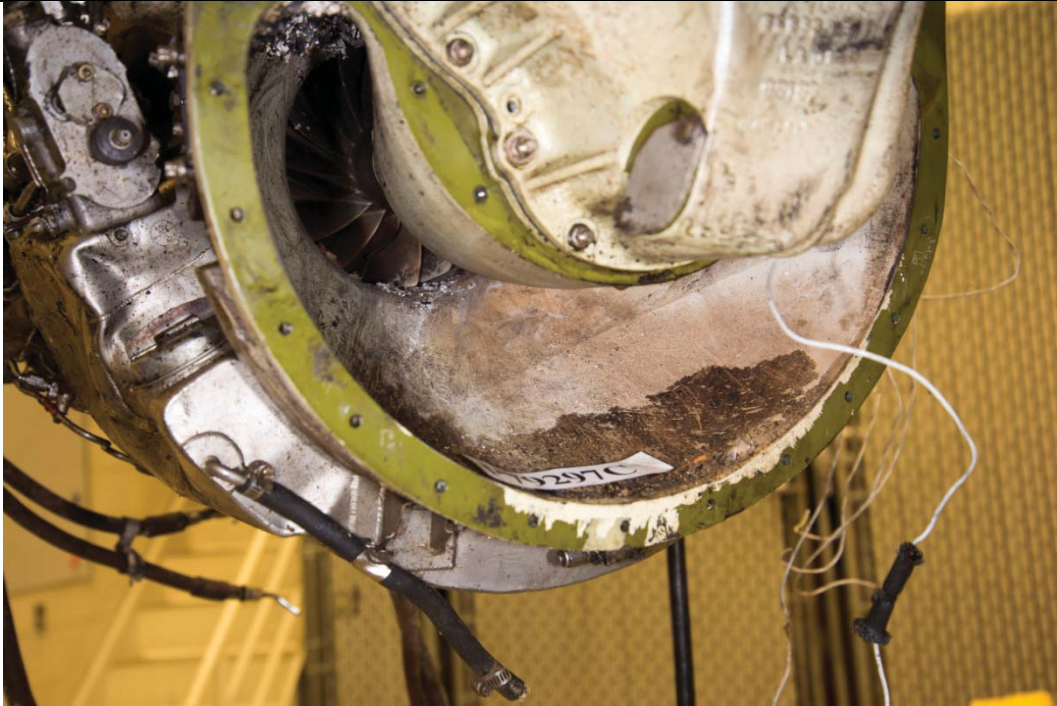




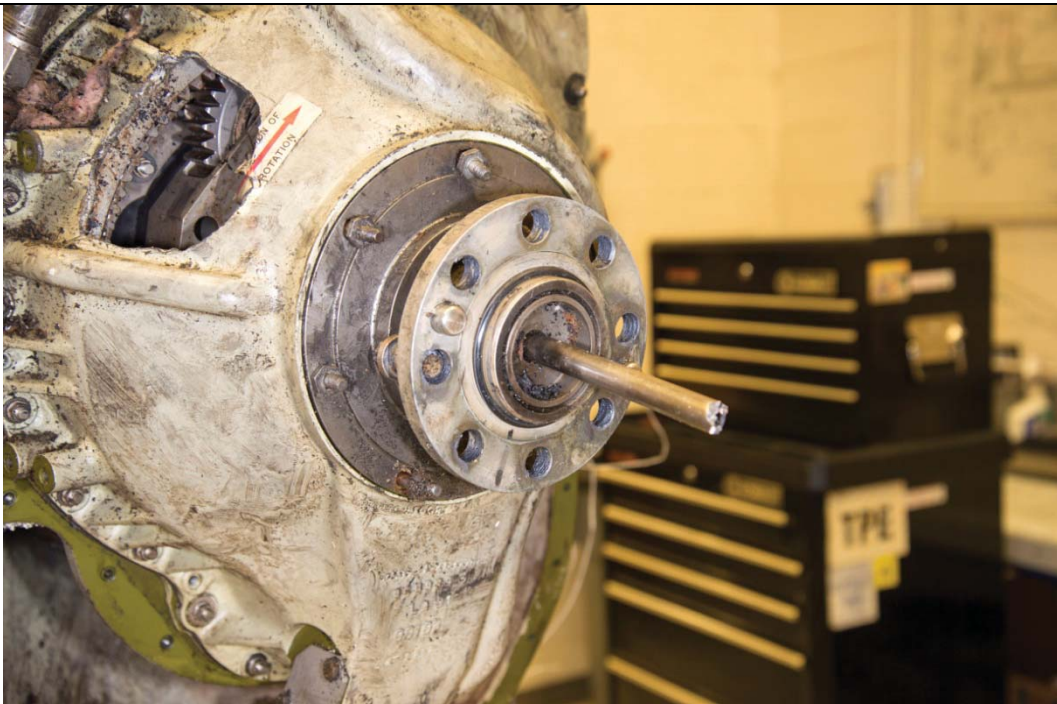
**Figure 7.** P-79297C, Turbine Section, ALF



**Figure 8.** P-79297C, Impact Damage



**Figure 9.** P-79297C, Debris in the Air Inlet Area

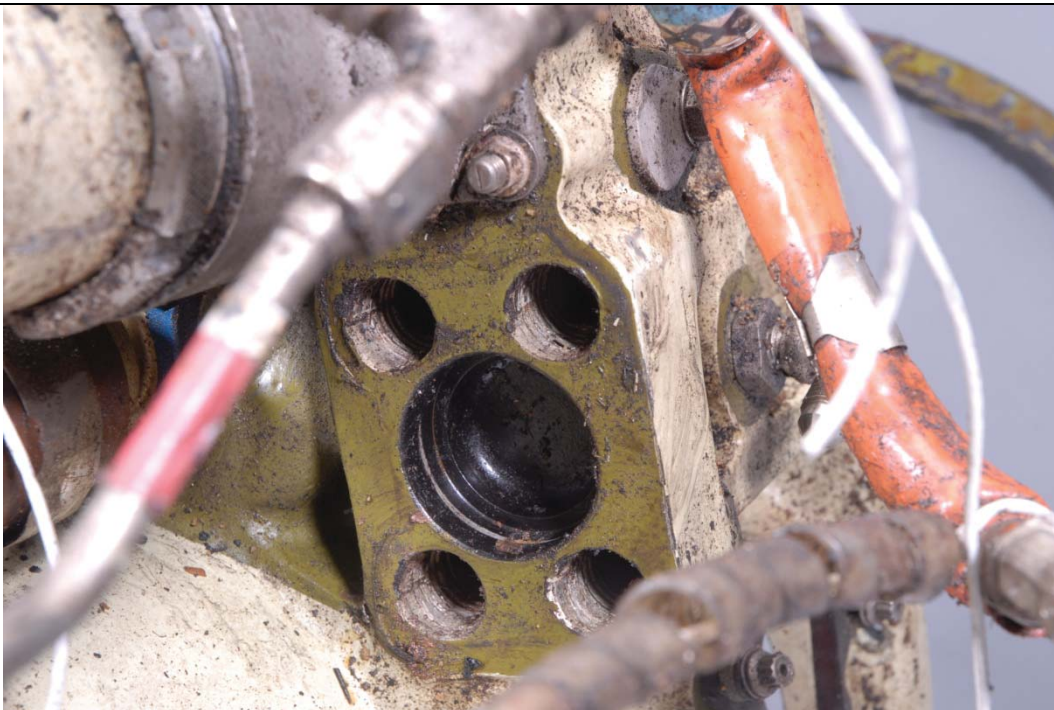


**Figure 10.** P-79297C, Fractured Beta Tube





**Figure 11. P-79297C, Upper Gearcase Mount**



**Figure 12. P-79297C, Right Gearcase Mount**



**Figure 13. P-79297C, Left Gearcase Mount**



**Figure 14. P-79297C, Aft Engine Mount**

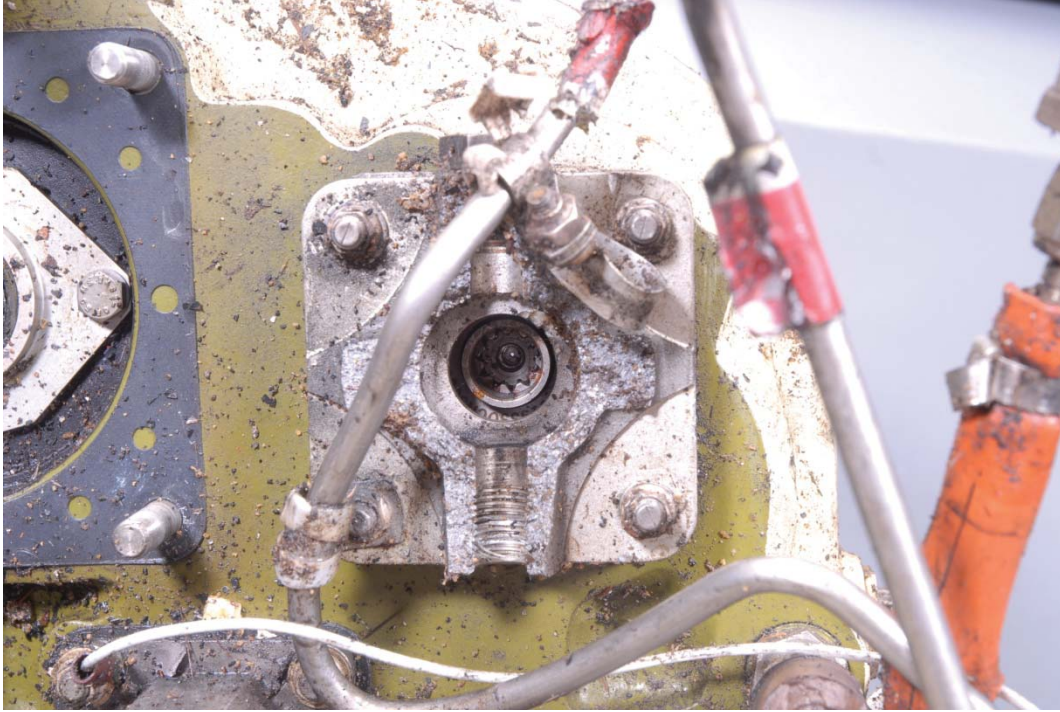




**Figure 15.** P-79297C, Starter/Generator Fractured Input Shaft



**Figure 16.** P-79297C, Fuel Control and Fuel Pump Assembly



**Figure 17.** P-79297C, Fuel Pump Mount to Engine Case

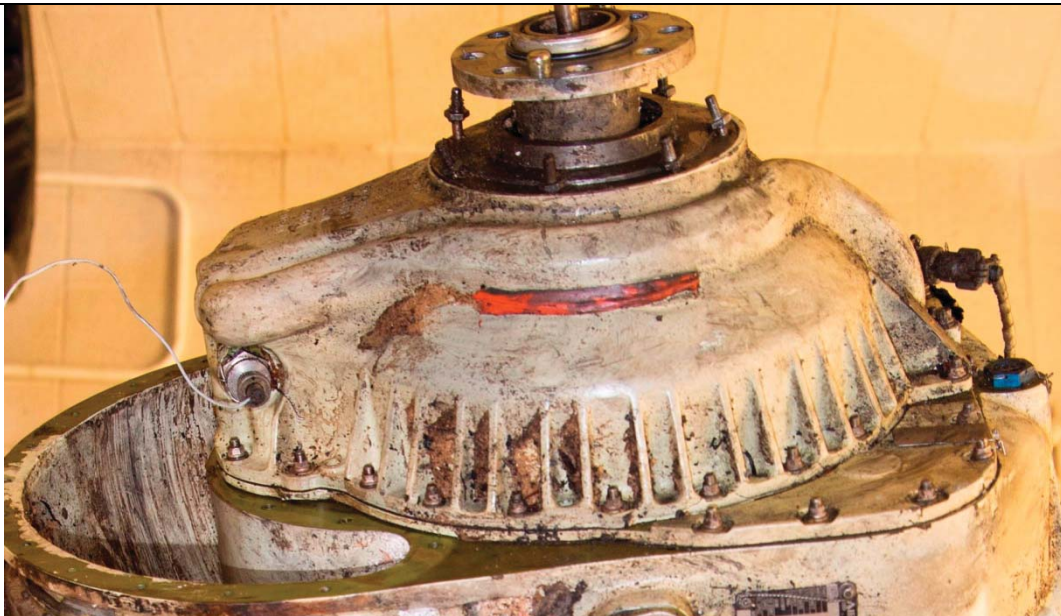


**Figure 18.** P-79297C, Nose Cone Assembly, Cracks/Fractures





**Figure 19.** P-79297C, Nose Cone Assembly, Cracks/Fractures



**Figure 20.** P-79297C, Nose Cone Assembly



**Figure 21.** P-79297C, Nose Cone, Internal Debris



**Figure 22.** P-79297C, Propeller Mount Flange Alignment Dowels, FLA





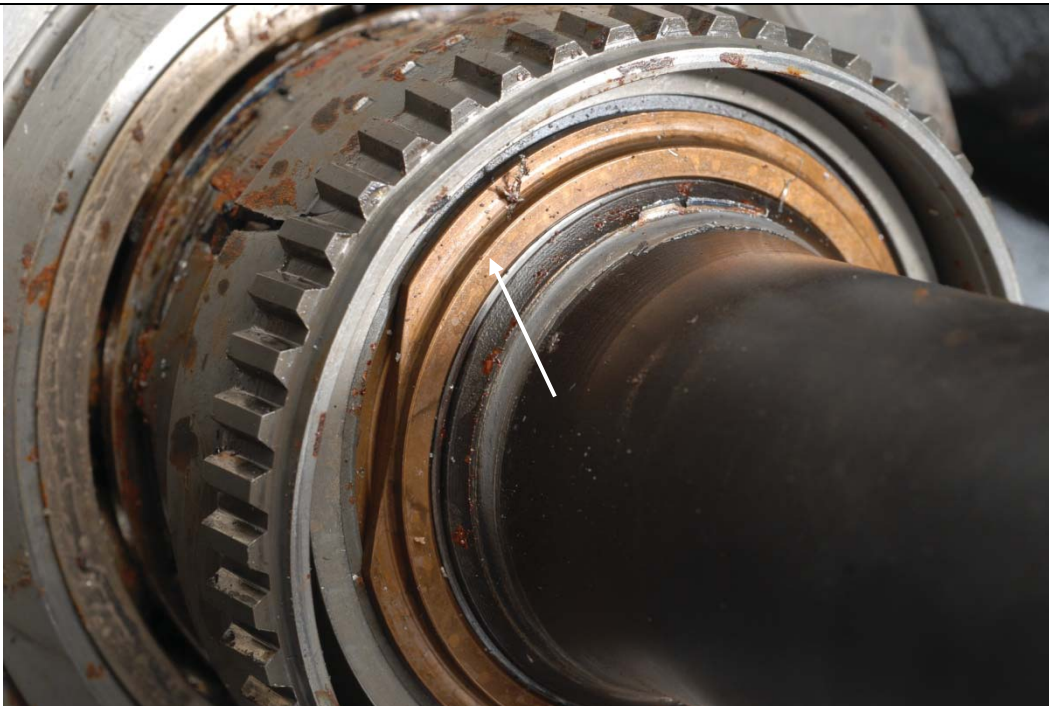
**Figure 23.** P-79297C, Forward Propeller Shaft Mounting Bolts



**Figure 24.** P-79297C, Propeller Shaft Rotational Scoring



**Figure 25.** P79297C, Propeller Shaft Rotational Scoring, Aft Taper

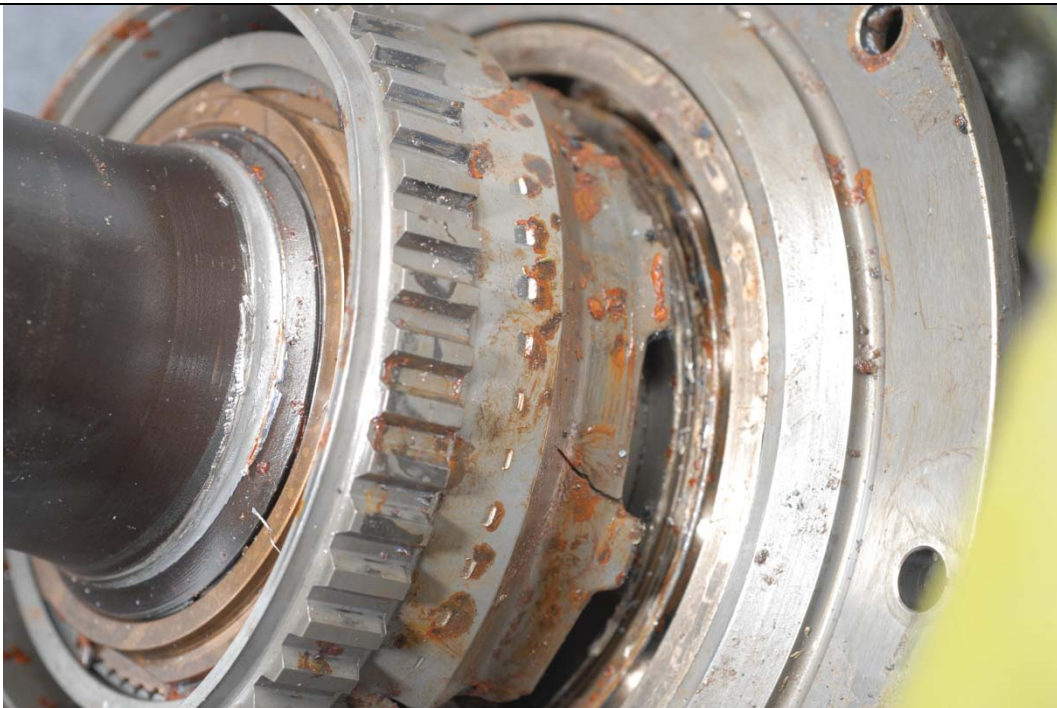


**Figure 26.** P-79297C, Propeller Shaft Lock Nut





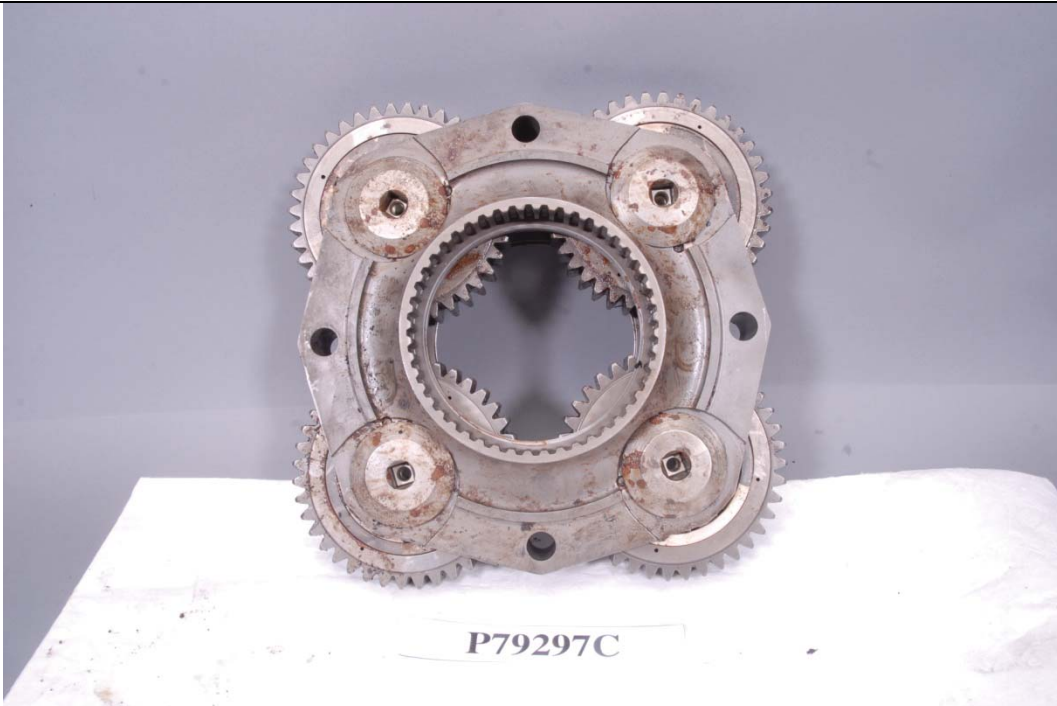
**Figure 27. P-79297C, Propeller Shaft Oil Jet**



**Figure 28. P-79297C, Propeller Shaft Coupler**



**Figure 29.** P-79297C, Propeller Shaft Coupler, Impact Damage

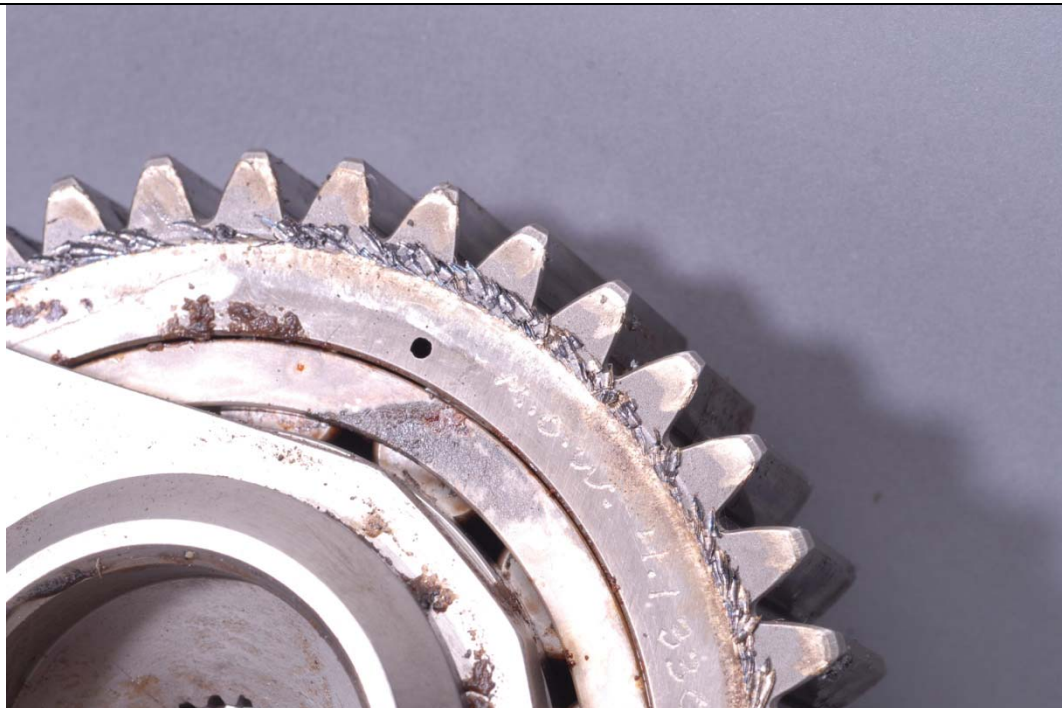


**Figure 30.** P-79297C, Planetary Gear Assembly, FLA





**Figure 31.** P-79297C, Planetary Geat Assembly, ALF



**Figure 32.** P-79297C, Planetary Gear Score Marks (6), FLA



**Figure 33.** P-79297C, Ring Gear Assembly Installed in Intermediate Case, FLA



**Figure 34.** P-79297C, Ring Gear Bumper Plate Scoring Marks, FLA

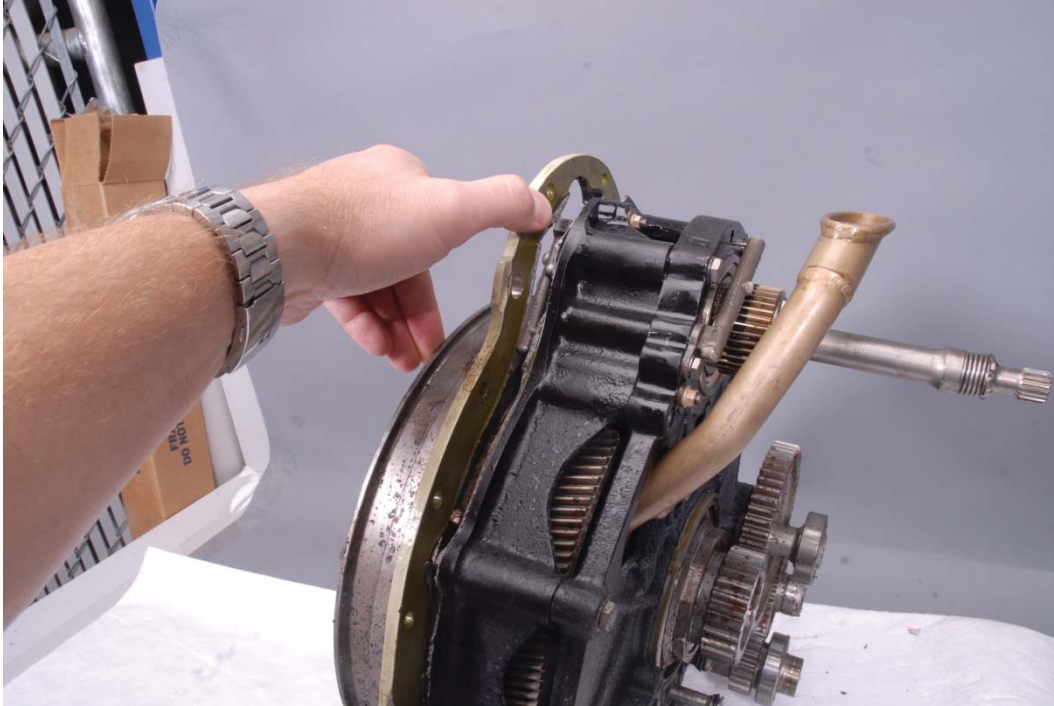


**Figure 35. P-79297C, Diaphragm Housing, ALF**

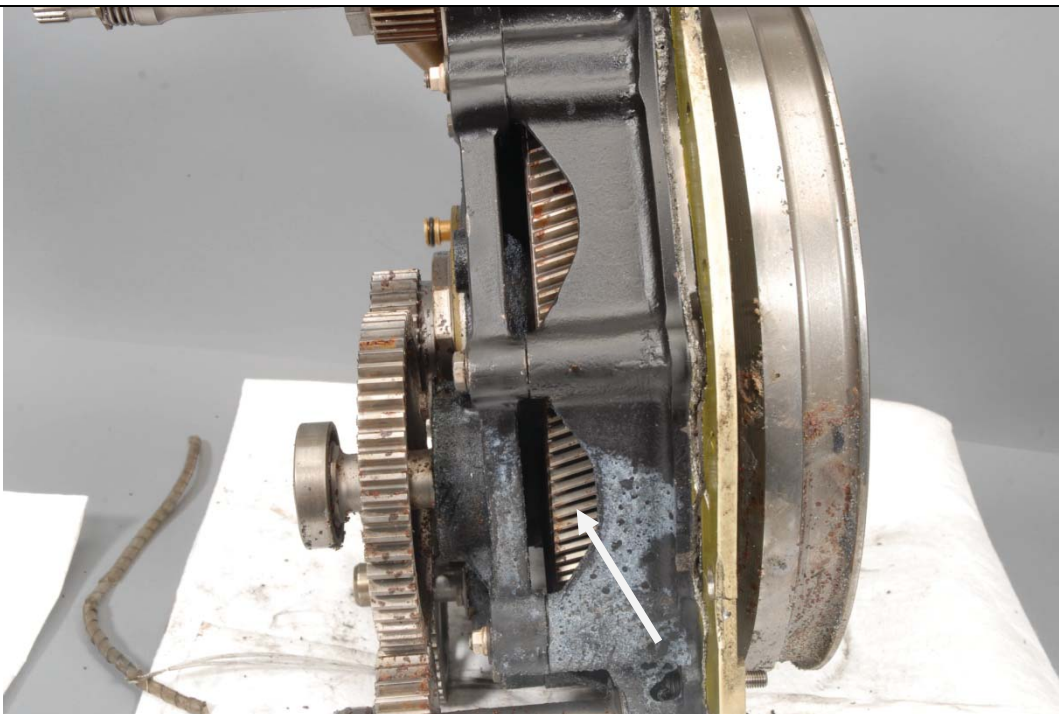


**Figure 36. P-79297C, Diaphragm Housing, FLA**





**Figure 37. P-79297C, Diaphragm Housing Fracture**



**Figure 38. P-79297C, Bull Gear**



**Figure 39.** P-79297C, Forward Bull Gear Bearing

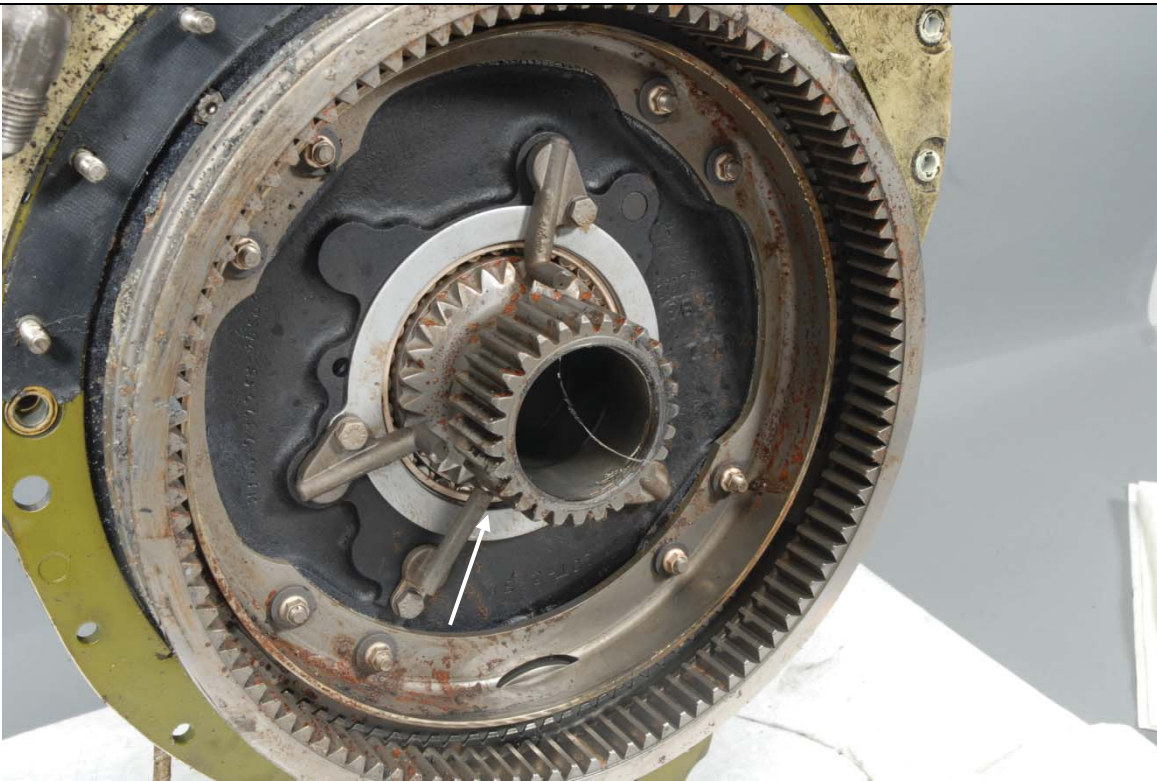


**Figure 40.** P-79297C, Aft Bull Gear Bearing and Liner, Displaced Aft





**Figure 41.** P-79297C, Aft Bull Gear Bearing Liner Impact Mark



**Figure 42.** P-79297C, Sun Gear





Figure 43. P-79297C, Sun Gear, Rotational Scoring

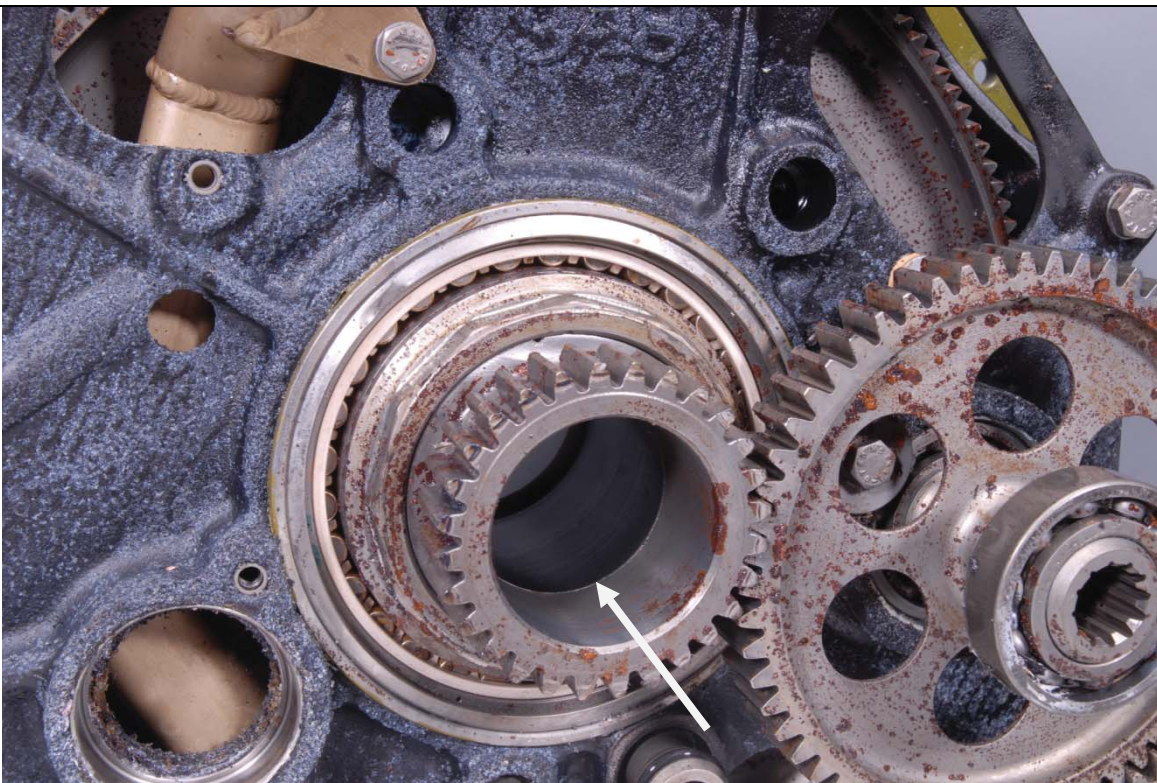


Figure 44. P-79297C, Sun Gear, Forward Inner Bore Rotational Scoring, FLA

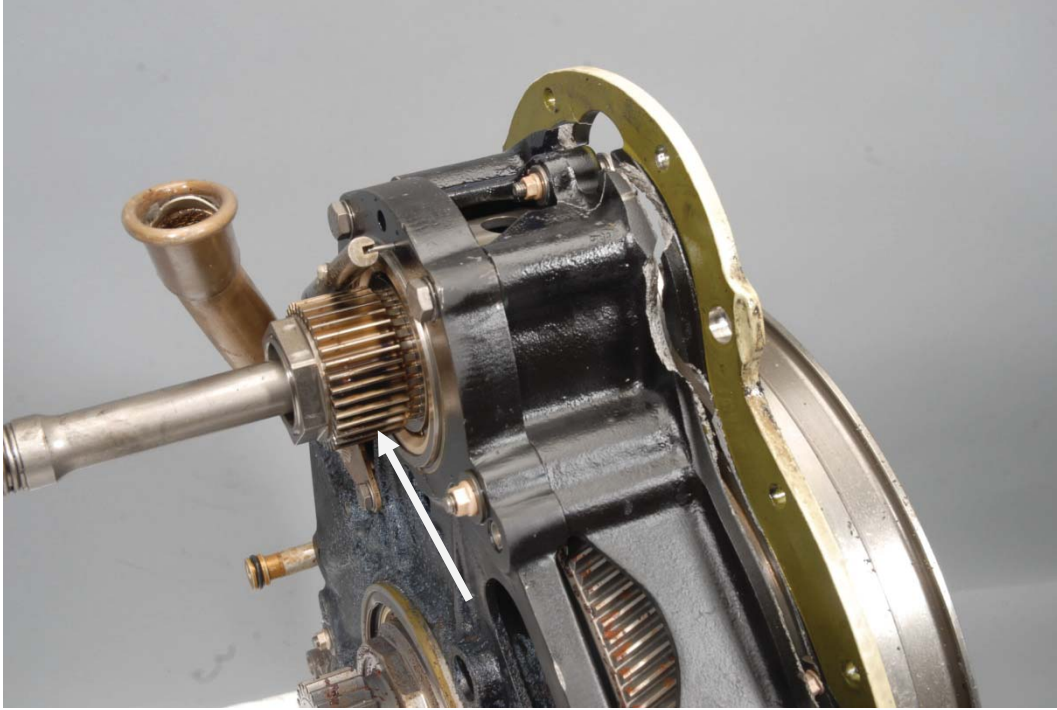




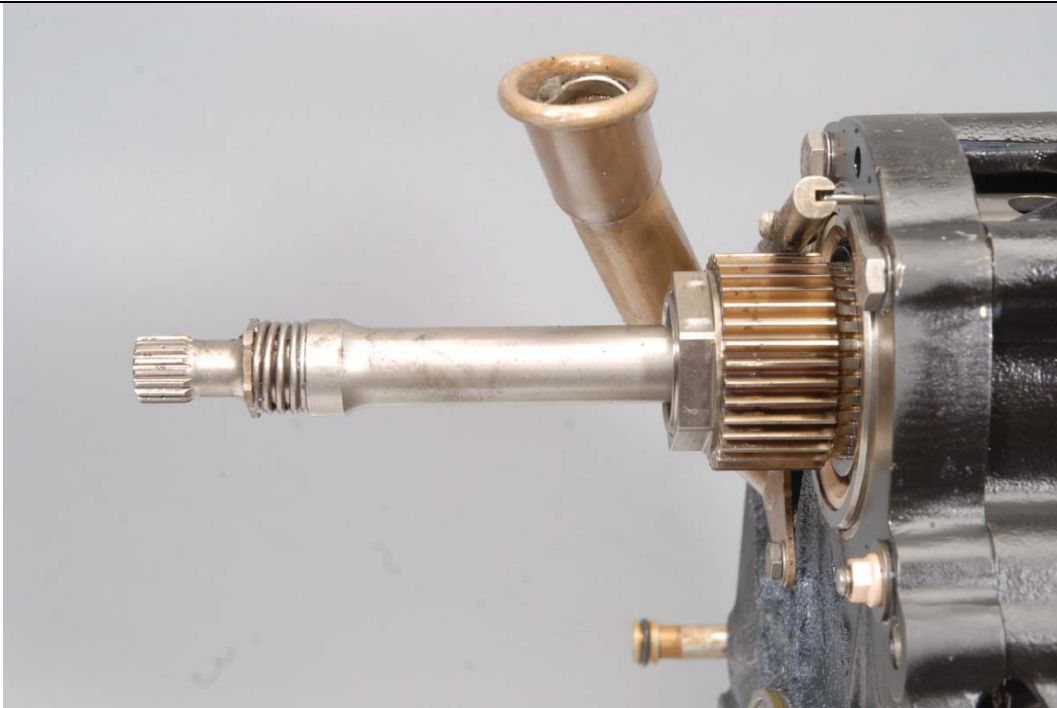
**Figure 45.** P-79297C, Sun Gear, Aft Face Rotational Scoring, ALF



**Figure 46.** P-79297C, Sun Gear Nut Rotational Scoring, ALF



**Figure 47. P-79297C, High Speed Pinion Gear**

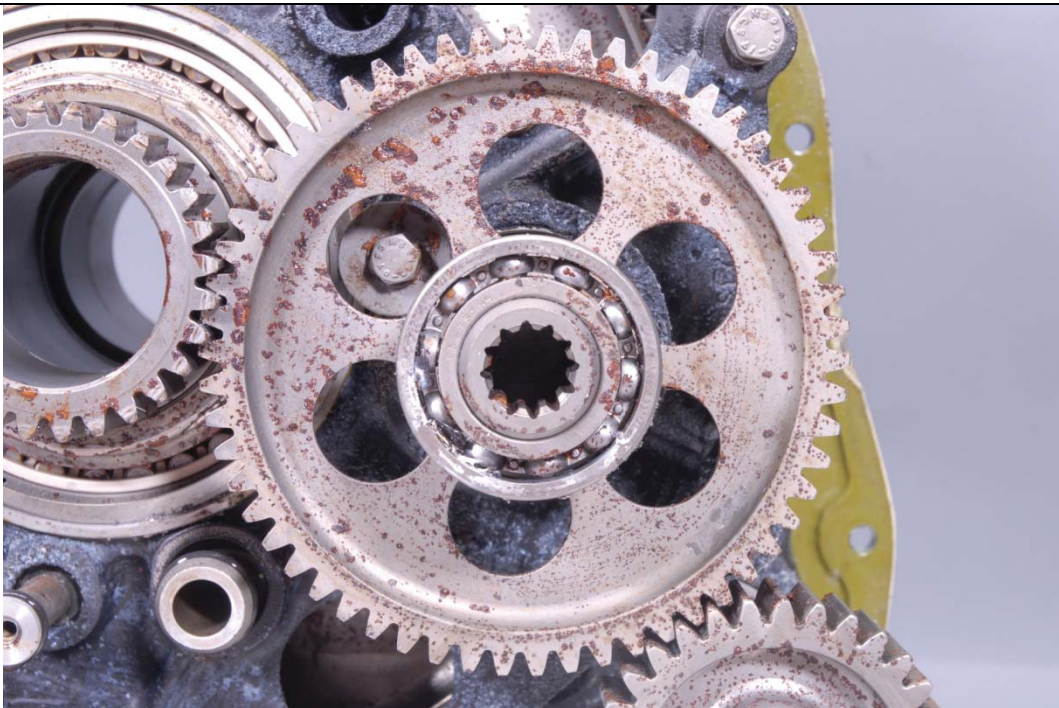


**Figure 48. P-79297C, HSP-to-Power Section Coupling Shaft Assembly**

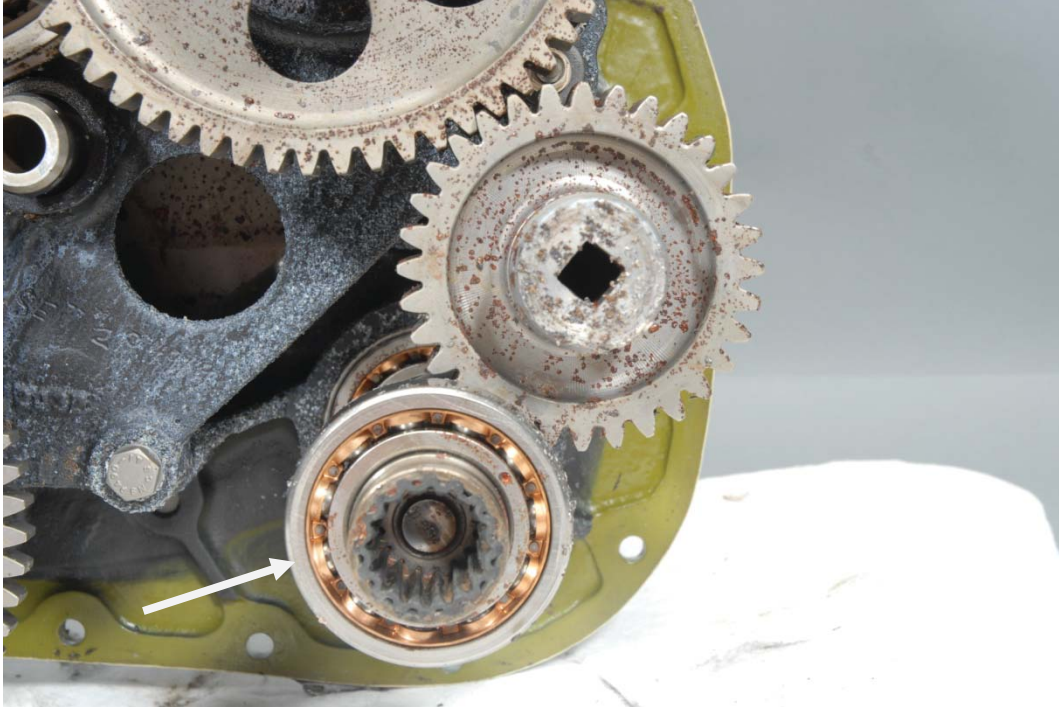




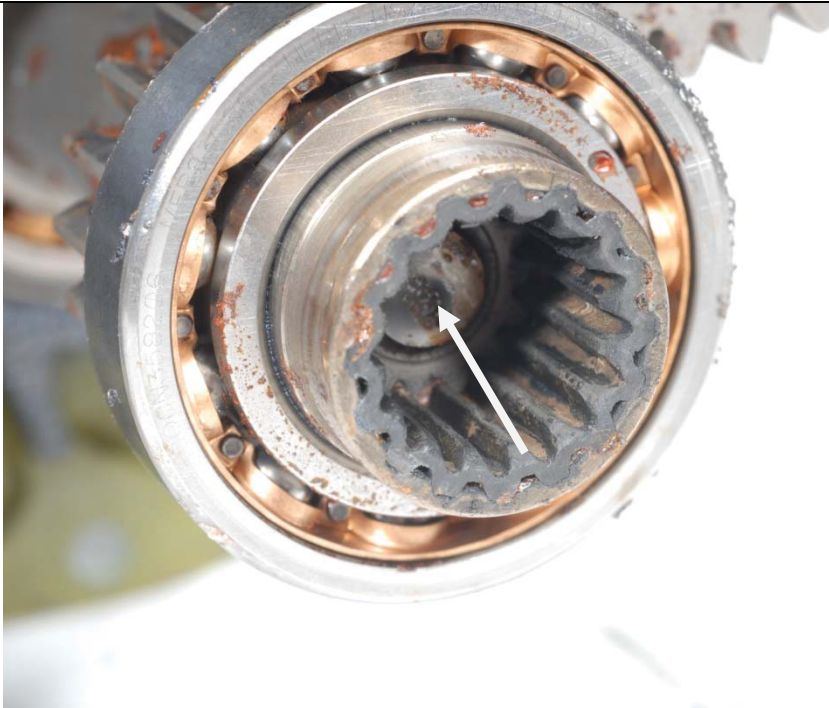
**Figure 49.** P-79297C, Hydraulic Pump Drive Gearshaft Assembly



**Figure 50.** P-79297C, Propeller Governor Drive Gear Assembly

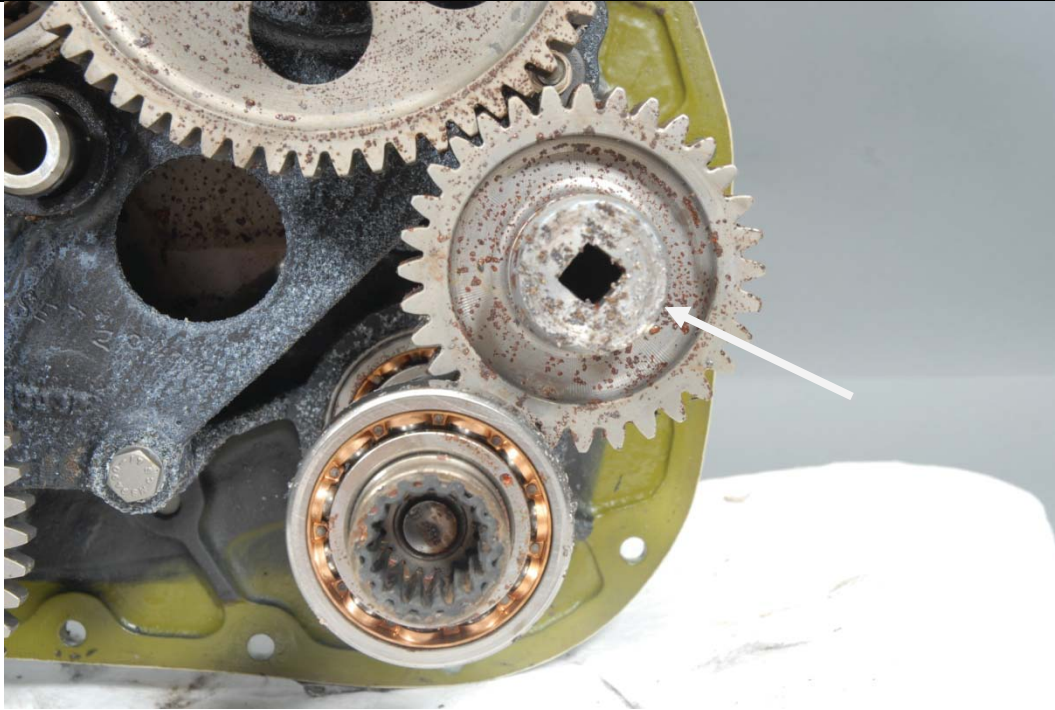


**Figure 51.** P-79297C, Starter/Generator Drive Gearshaft Assembly



**Figure 52.** P-79297C, Drive Portion of the Starter/Generator Gear Shaft





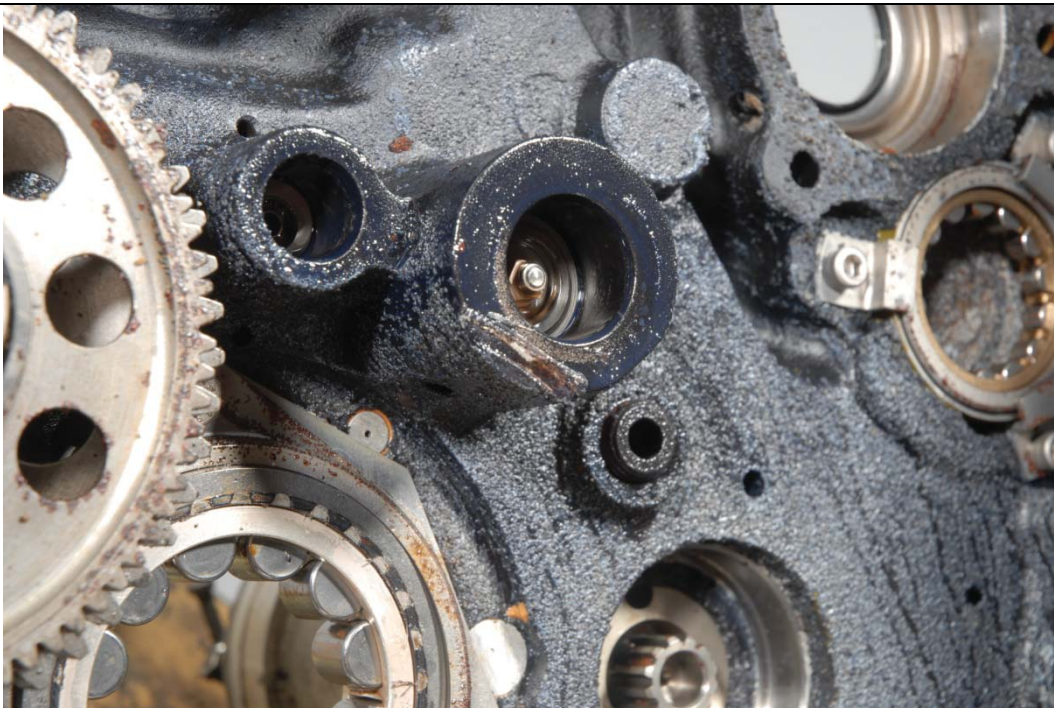
**Figure 53. P-79297C, Starter/Generator Idler Gear Assembly**



**Figure 54. P-79297C, Exterior (non oil-wetted) Surfaces of the Gearcase Housing**

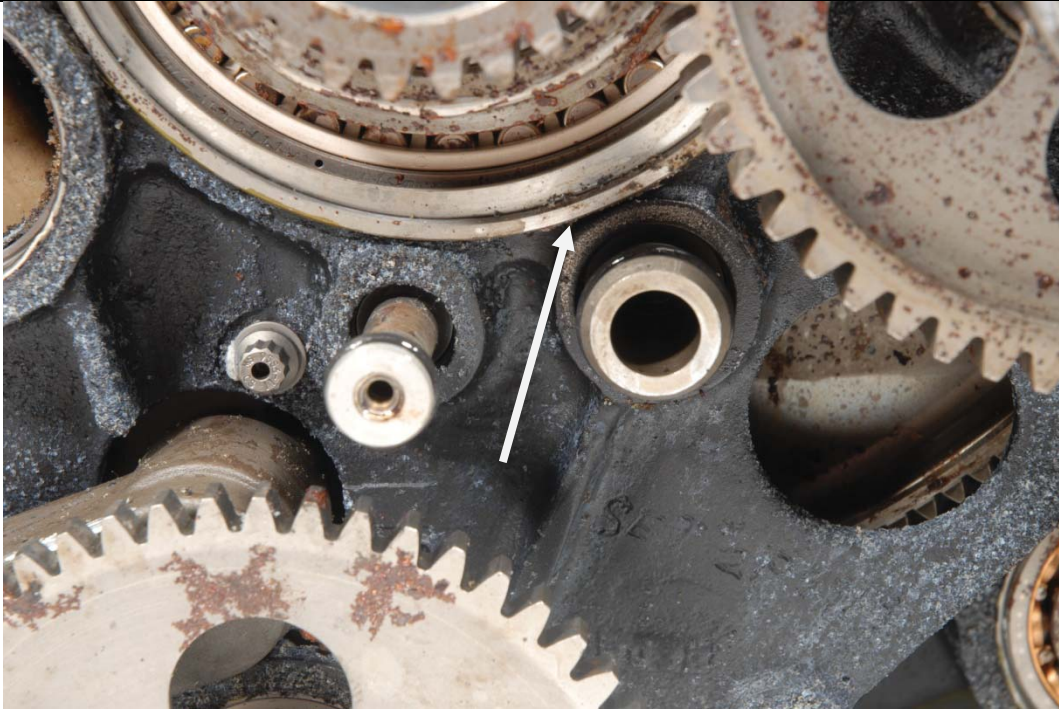


**Figure 55. P-79297C, Interior (oil-wetted) Surfaces of the Gearcase Housing**



**Figure 56. P-79297C, Impact Mark on the Feather Valve Oil Transfer Tube Boss**





**Figure 57.** P-79297C, Witness Mark on the Aft Bull-Gear Bearing Outer Race Liner



**Figure 58.** P-79297C, Interior of the Gearcase Housing





**Figure 59.** P-79297C, Anti-Ice Shield



**Figure 60.** P-79297C, Aft Propeller Shaft Aft Ball Bearing



**Figure 61.** P-79297C, Aft Propeller Shaft Roller Bearing



**Figure 62.** P-79297C, Aft Prop Shaft Roller Bearing, Rotational Scoring





**Figure 63. P-79297C, Forward (Compressor) Main-Shaft Nut, FLA**



**Figure 64. P-79297C, Main Shaft Gear, FLA**



**P79297C**

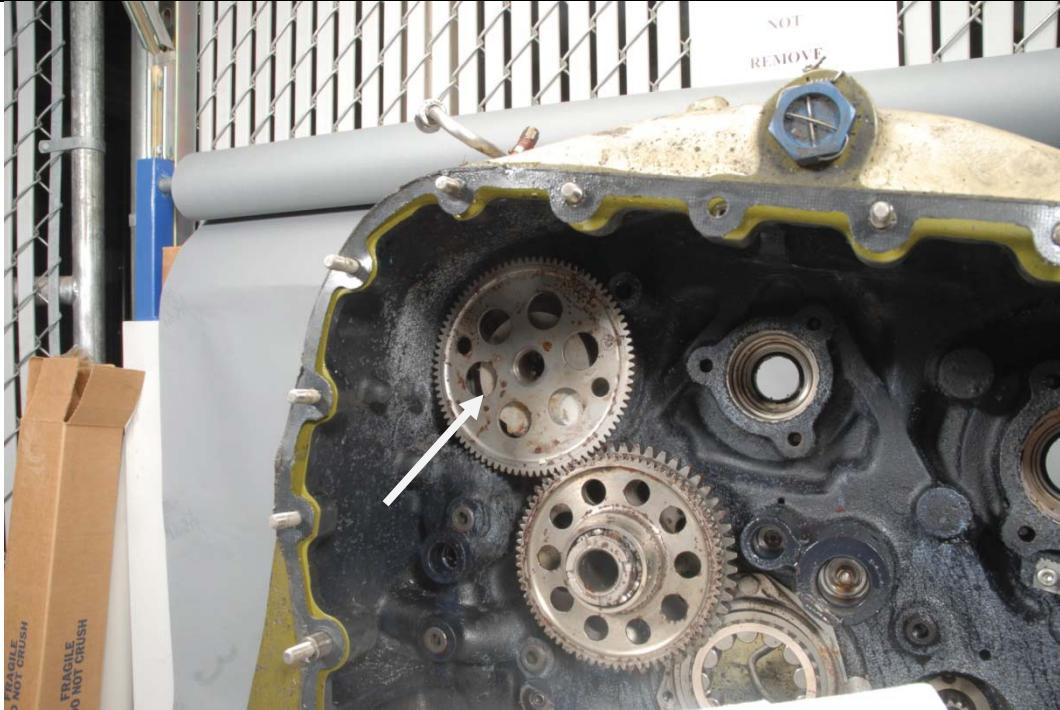


**Figure 67.** P-79297C, Compressor Air/Oil Carbon Seal Rotor, FLA

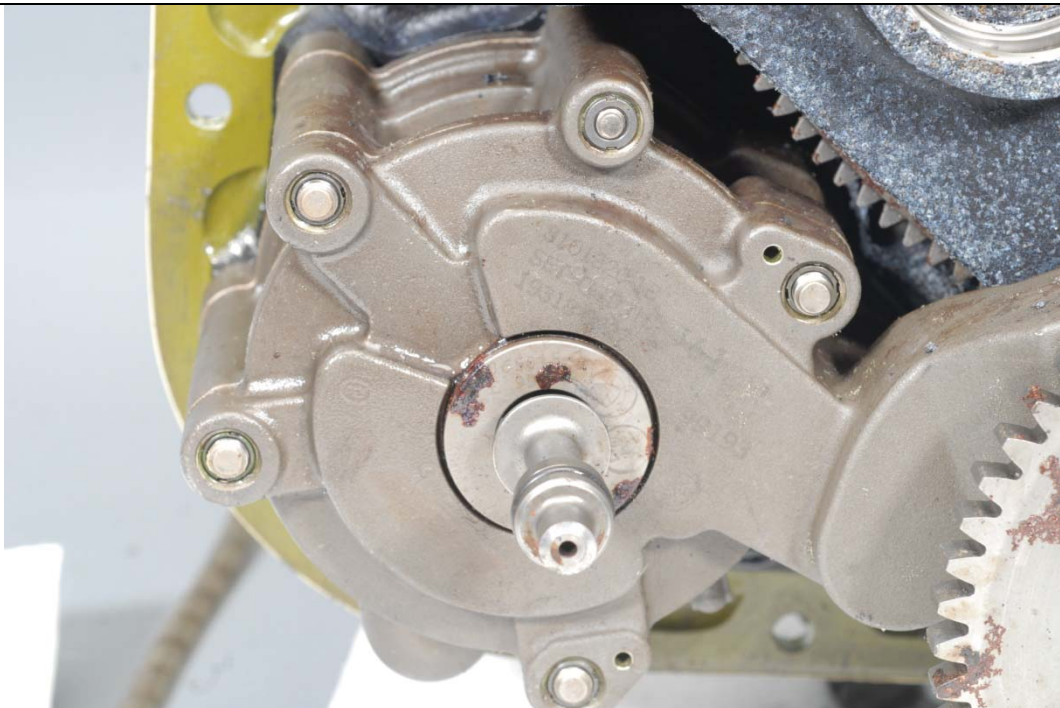


**Figure 68.** P-79297C, Magnetic Drain Plug (chip detector)





**Figure 69.** P-79297C, Oil Pressure Pump

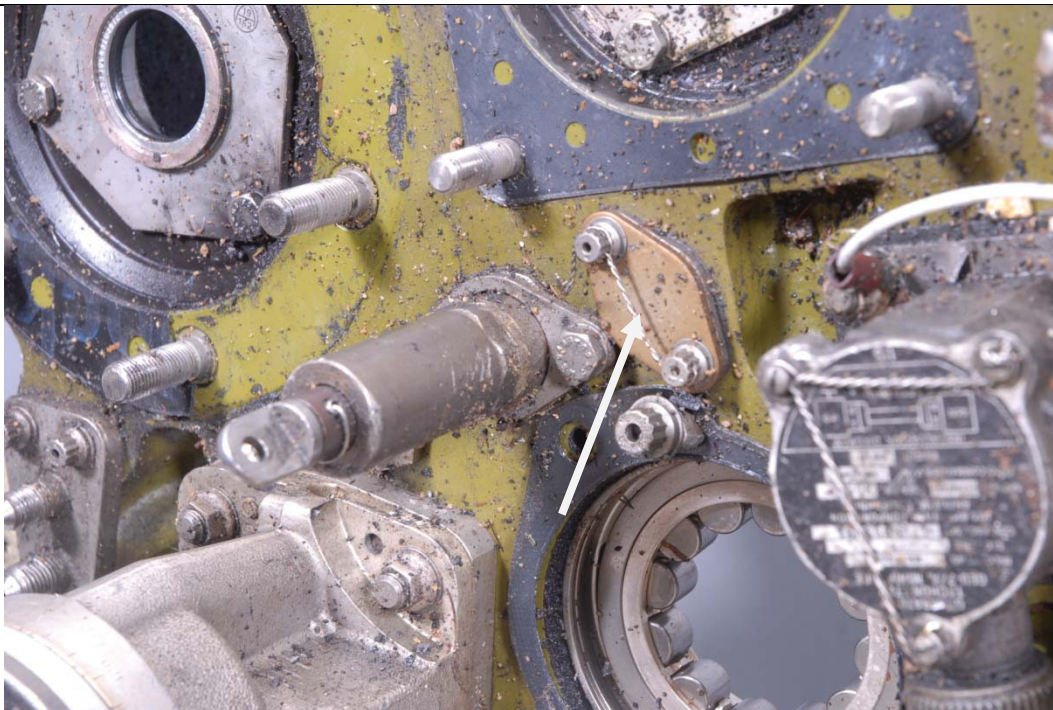


**Figure 70.** P-79297C, Gearcase Oil-Scavenge Pump





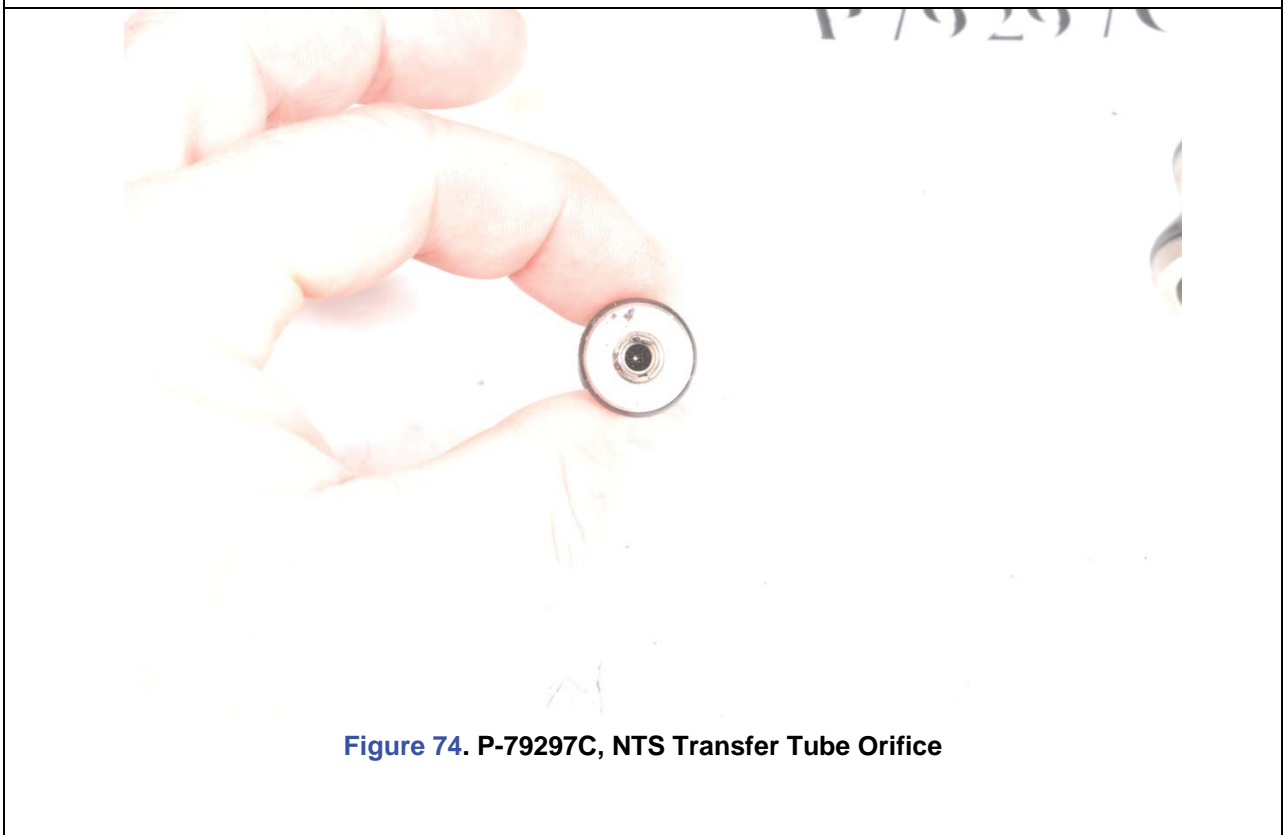
**Figure 71.** P-79297C, Gearcase Oil-Scavenge Pump Driveshaft



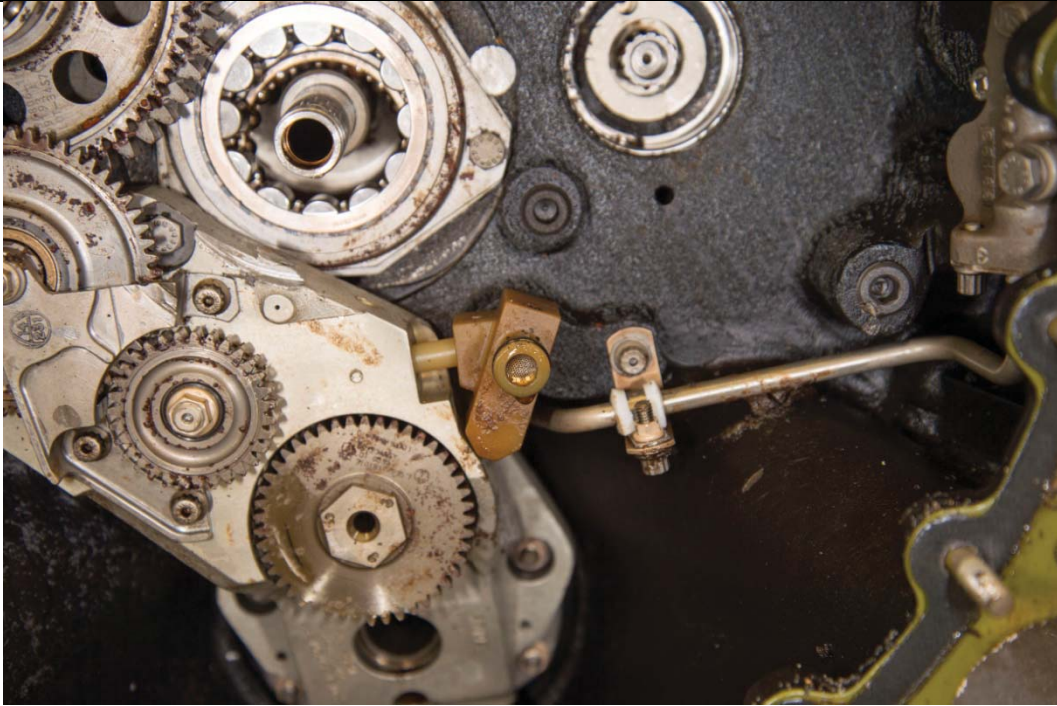
**Figure 72.** P-79297C, Negative Torque Sensing Regulator, ALF



**Figure 73.** P-79297C, NTS Transfer Tube/Restrictor Assembly and Feather Valve Oil Transfer Tube



**Figure 74.** P-79297C, NTS Transfer Tube Orifice



**Figure 75. P-79297C, Torque Sensor Oil Screen**

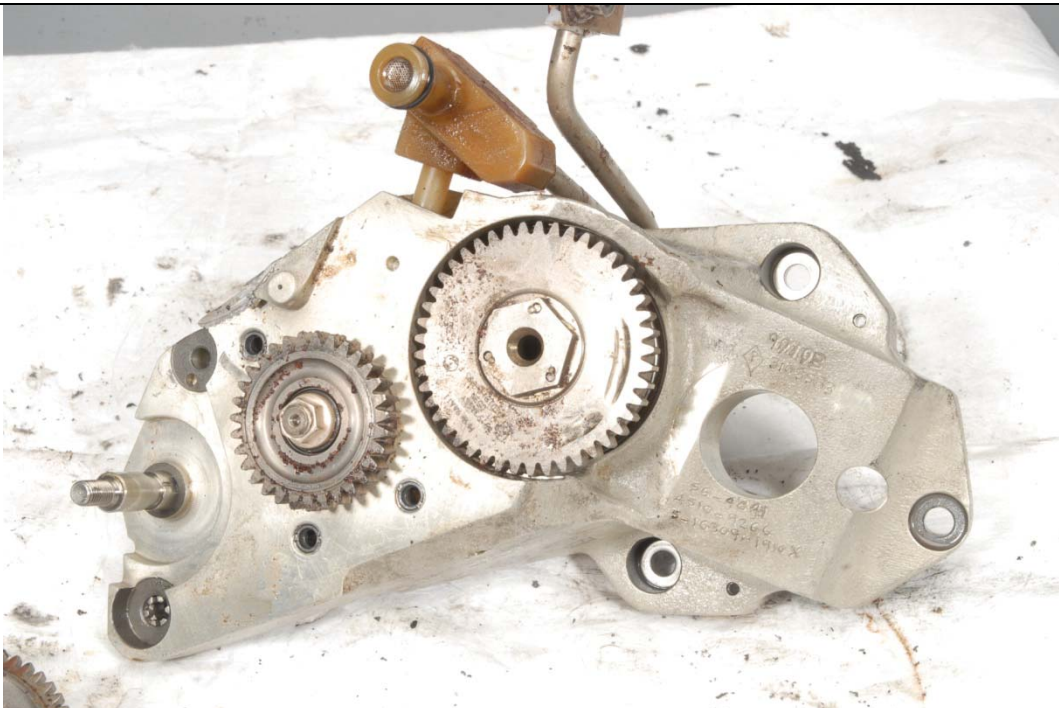


**Figure 76. P-79297C, Propeller Governor "Spider" Gasket**





**Figure 77.** P-79297C, Propeller Governor Reset Orifice



**Figure 78.** P-79297C, Torque Sensor

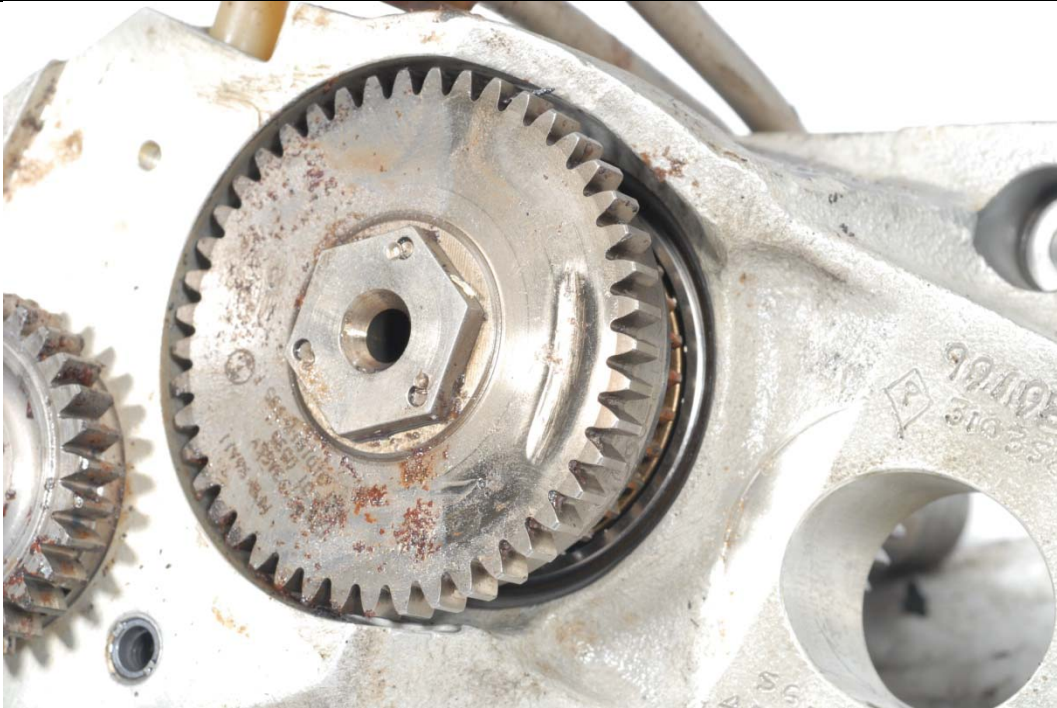




**Figure 79.** P-79297C, Rotational Scoring on the Forward Housing Surface



**Figure 80.** P-79297C, Static Impact Marks on the Forward Surface of the Torque Sensor



**Figure 81.** P-79297C, Helical Cam Gear

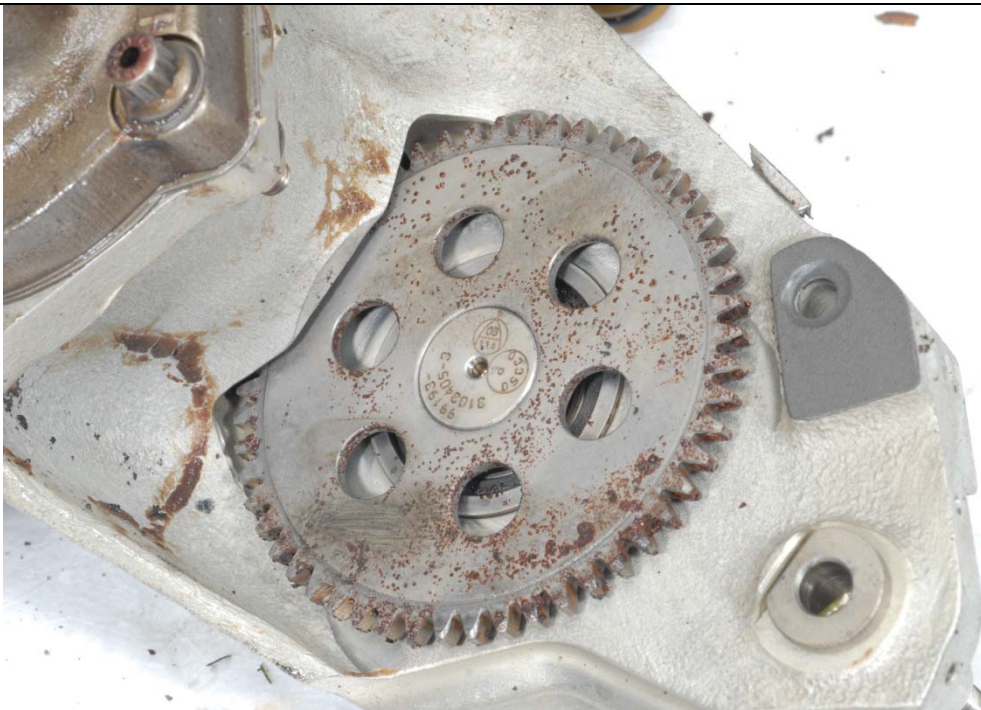


**Figure 82.** P-79297C, First Direct Drive Fuel-Control (DDFC) Gear





**Figure 83.** P-79297C, Second DDFC Gear, FLA



**Figure 84.** P-79297C, Second DDFC Gear, ALF





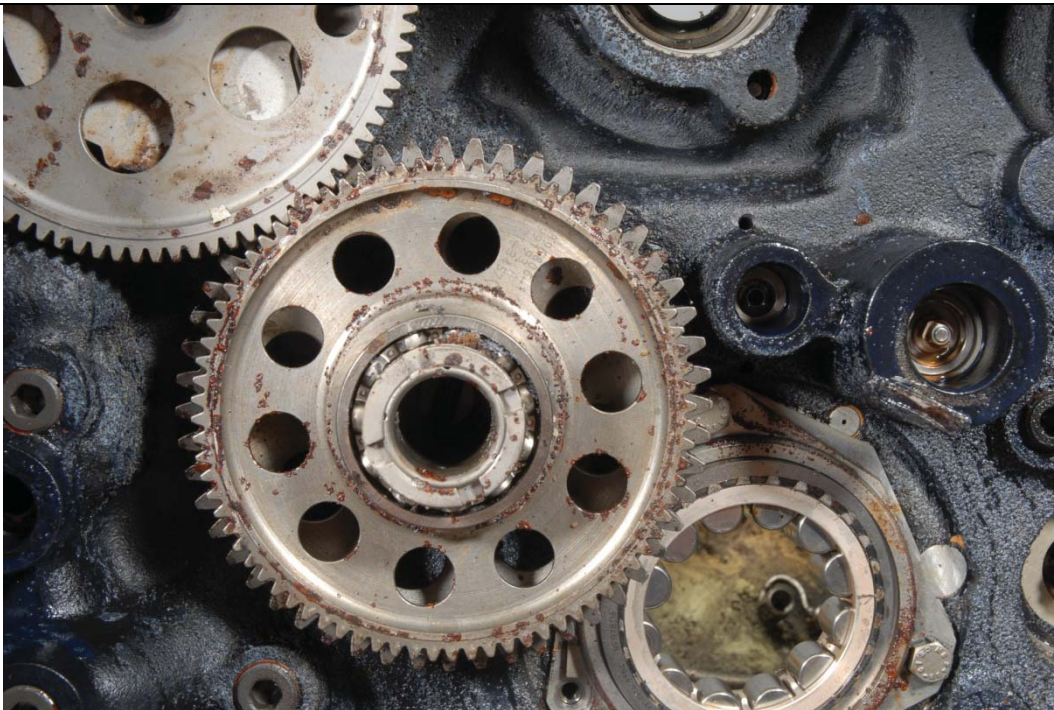
**Figure 85.** P-79297C, Third DDFC Gear, FLA



**Figure 86.** P-79297C, Third DDFC Gear, ALF



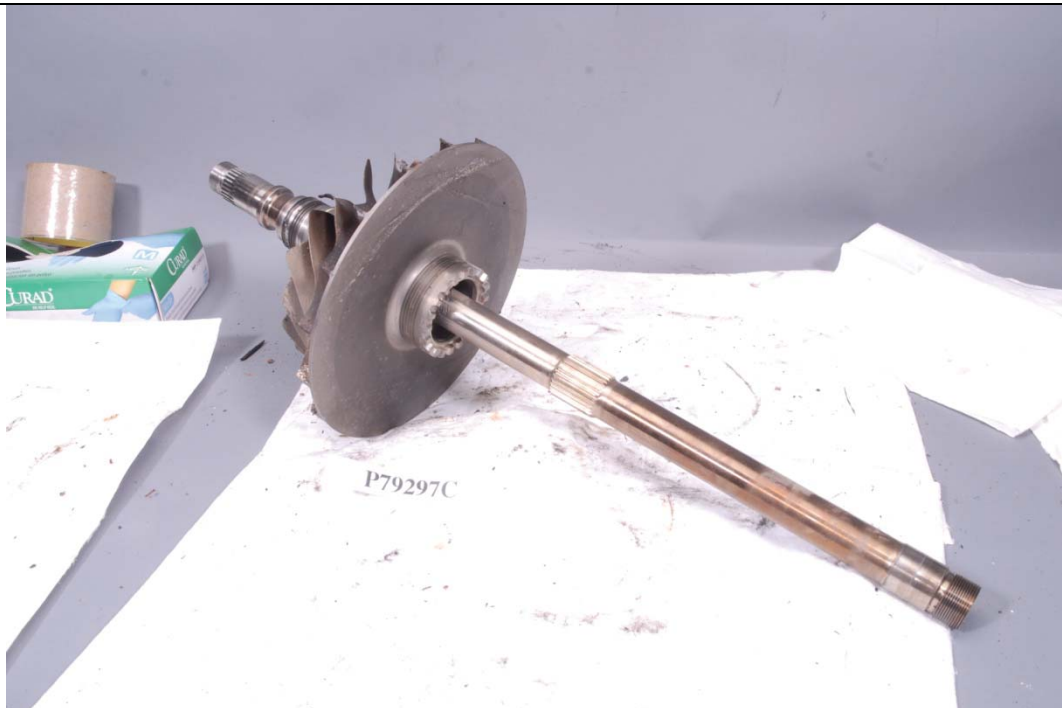
**Figure 87.** P-79297C, Third DDFC Gear



**Figure 88.** P-79297C, Fourth DDFC, Tach/Generator Drive Gear and Shaft Assembly



**Figure 89. P-79297C, Shouldered Main Shaft and First-Stage Compressor Impeller**



**Figure 90. P-79297C, Shouldered Main Shaft and First-Stage Compressor Impeller**





**Figure 91. P-79297C, Torsion Shaft**



79297C

**Figure 92. P-79297C, Torsion Shaft Shear Fracture**



**Figure 93.** P-79297C, First-Stage Compressor Impeller Shroud, ALF



**Figure 94.** P-79297C, First-Stage Compressor Impeller Shroud, FLA



**Figure 95.** P-79297C, First-Stage Compressor Impeller Shroud Rub



**Figure 96.** P-79297C, First-Stage Compressor Impeller, FLA





**Figure 97.** P-79297C, First-Stage Compressor Impeller, ALF



**Figure 98.** P-79297C, First-Stage Compressor Impeller, As Viewed Through the Inlet



**Figure 99.** P-79297C, First-Stage Compressor Impeller Shroud Line Scoring



**Figure 100.** P-79297C, First-Stage Compressor Impeller Leading Edge Erosion and Bending

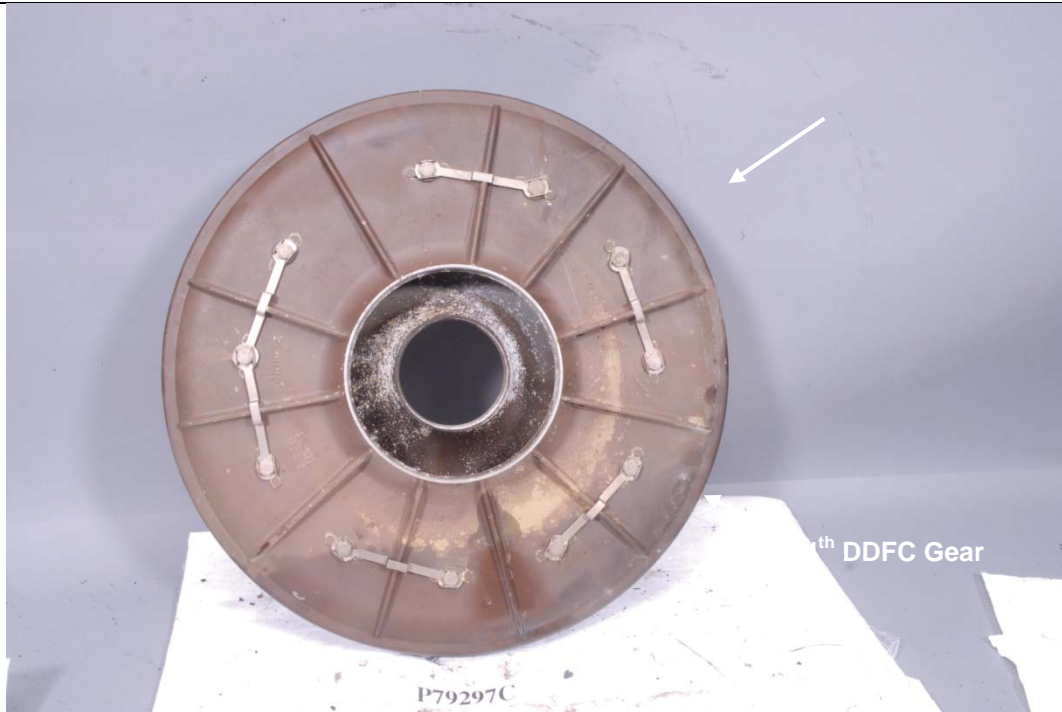


**Figure 101.** P-79297C, First-Stage Compressor Impeller Knife Seal Witness Marks



**Figure 102.** P-79297C, First-stage Compressor Diffuser, FLA





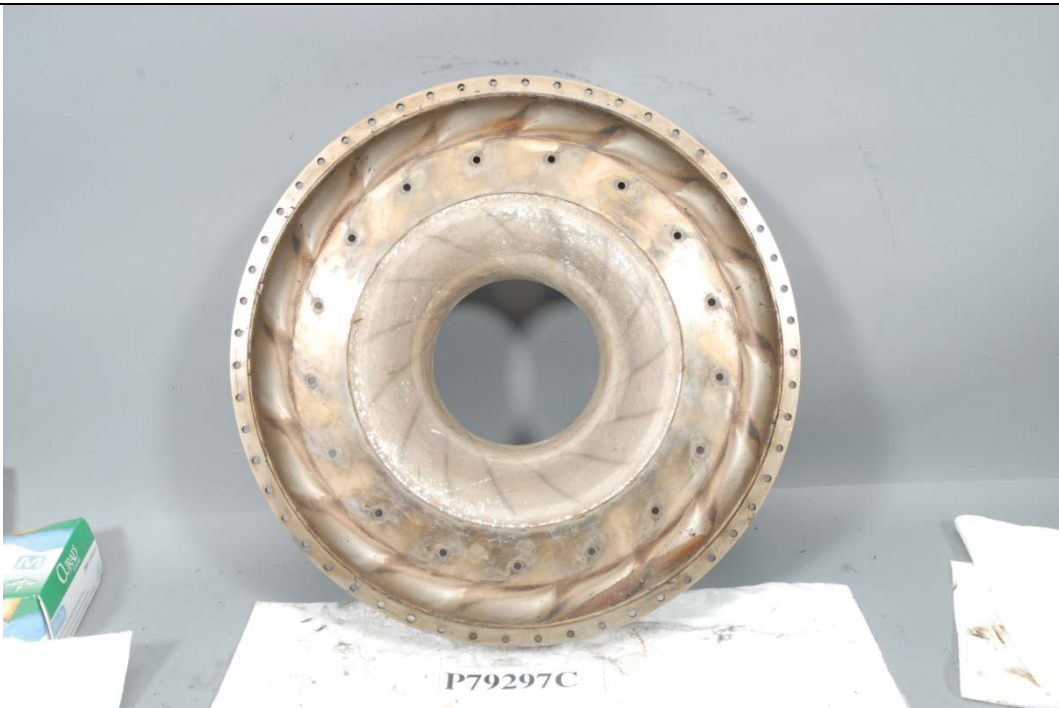
**Figure 103.** P-79297C, First-stage Compressor Diffuser, ALF



**Figure 104.** P-79297C, First-stage Compressor Diffuser Vane Leading Edge Damage

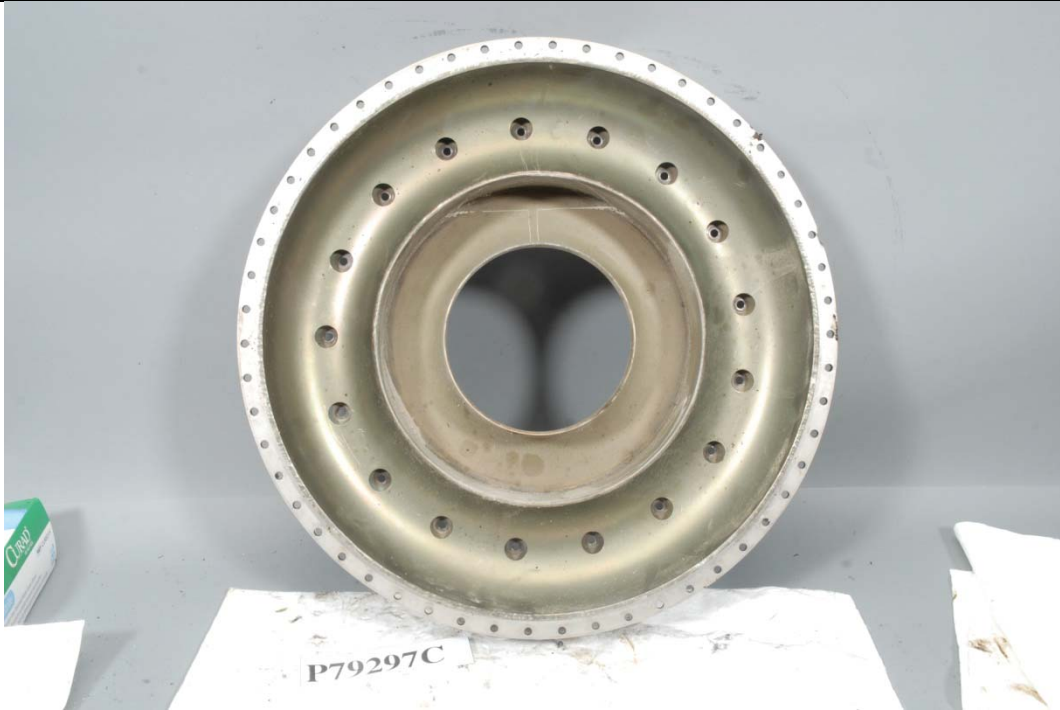


**Figure 105.** P-79297C, First-stage Compressor Diffuser, Debris Compacted in Flow Path



**Figure 106.** P-79297C, Second-Stage Compressor Housing, ALF



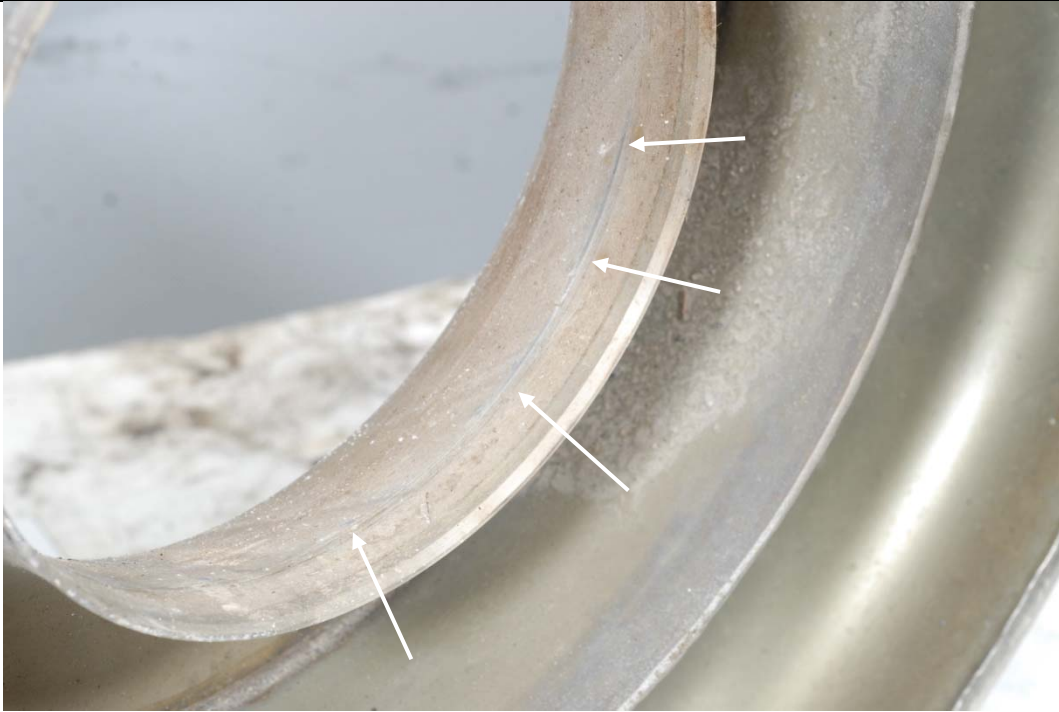


**Figure 107.** P-79297C, Second-Stage Compressor Housing, FLA



**Figure 108.** P-79297C, Second-Stage Compressor Housing





**Figure 109.** P-79297C, Second-Stage Compressor Housing Rotational Scoring



**Figure 110.** P-79297C, Second-Stage Compressor Impeller, FLA



**Figure 111.** P-79297C, Second-Stage Compressor Impeller, ALF



**Figure 112.** P-79297C, Second-Stage Compressor Impeller Forward Curvic



**Figure 113.** P-79297C, Second-Stage Compressor Impeller AFT Curvic



**Figure 114.** P-79297C, Second-Stage Compressor Impeller, Earthen Debris Deposits





**Figure 115.** P-79297C, Second-Stage Compressor Shroud Line Scoring



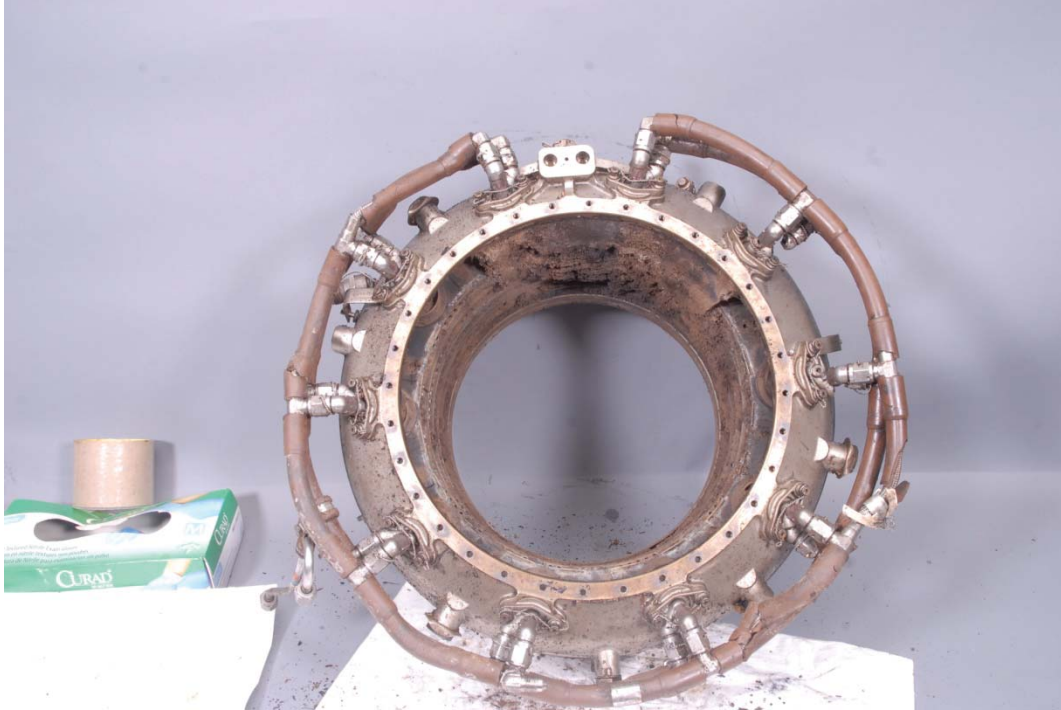
**Figure 116.** P-79297C, Second-Stage Compressor Diffuser Vane Assembly, FLA



**Figure 117.** P-79297C, Second-Stage Compressor Diffuser Vane Assembly, ALF



**Figure 118.** P-79297C, Second-Stage Compressor Diffuser Vane Assembly, Debris in Flow Path

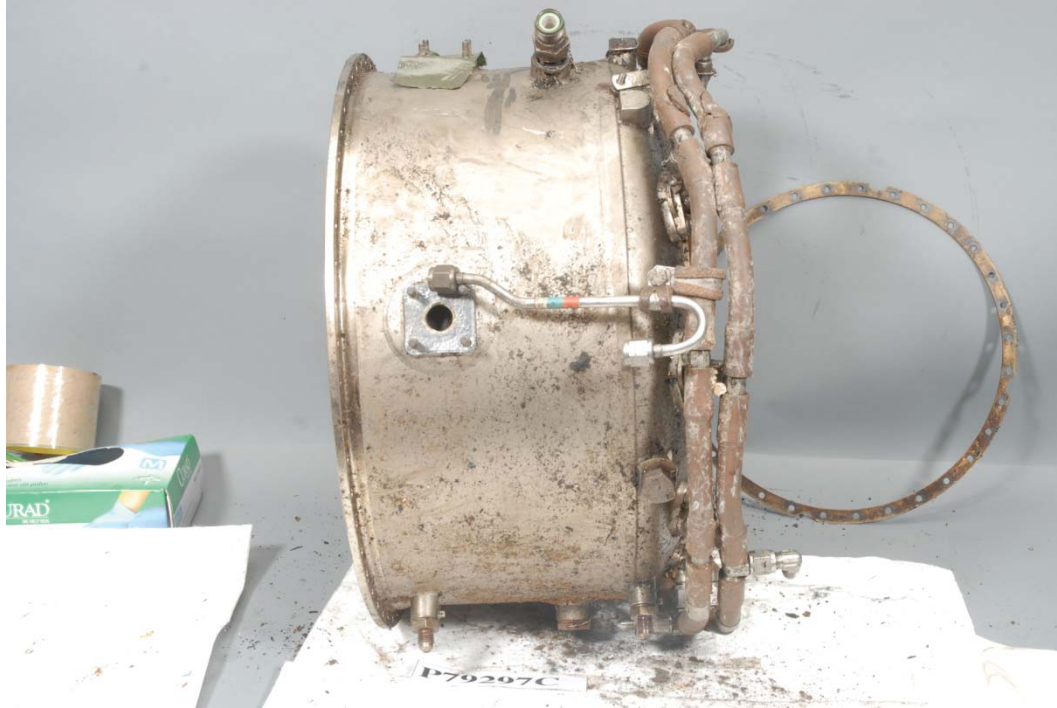


**Figure 119. P-79297C, Combustor Section Assembly, ALF**

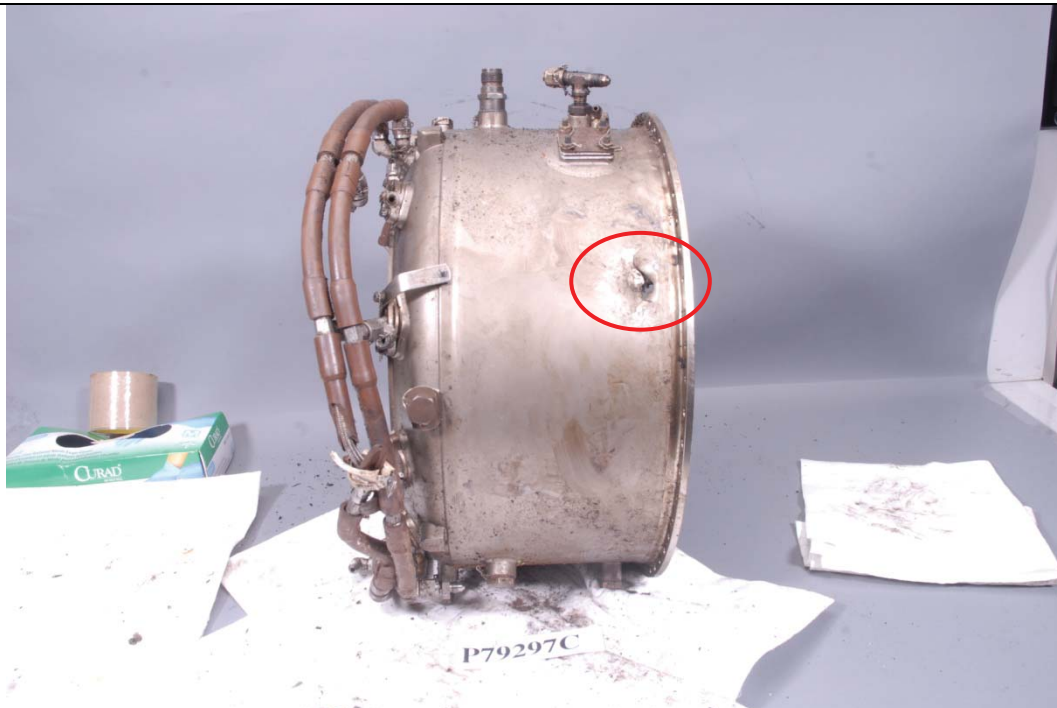


**Figure 120. P-79297C, Combustor Section Assembly, FLA**





**Figure 121. P-79297C, Combustor Plenum Case**



**Figure 122. P-79297C, Combustor Plenum Case, Impact Damage**



**Figure 123.** P-79297C, De-swirl Vane Assembly, Foreign Object Debris



**Figure 124.** P-79297C, Combustion Chamber, Earthen Debris





**Figure 125.** P-79297C, Combustion Chamber, Fuel Nozzle Swirlers

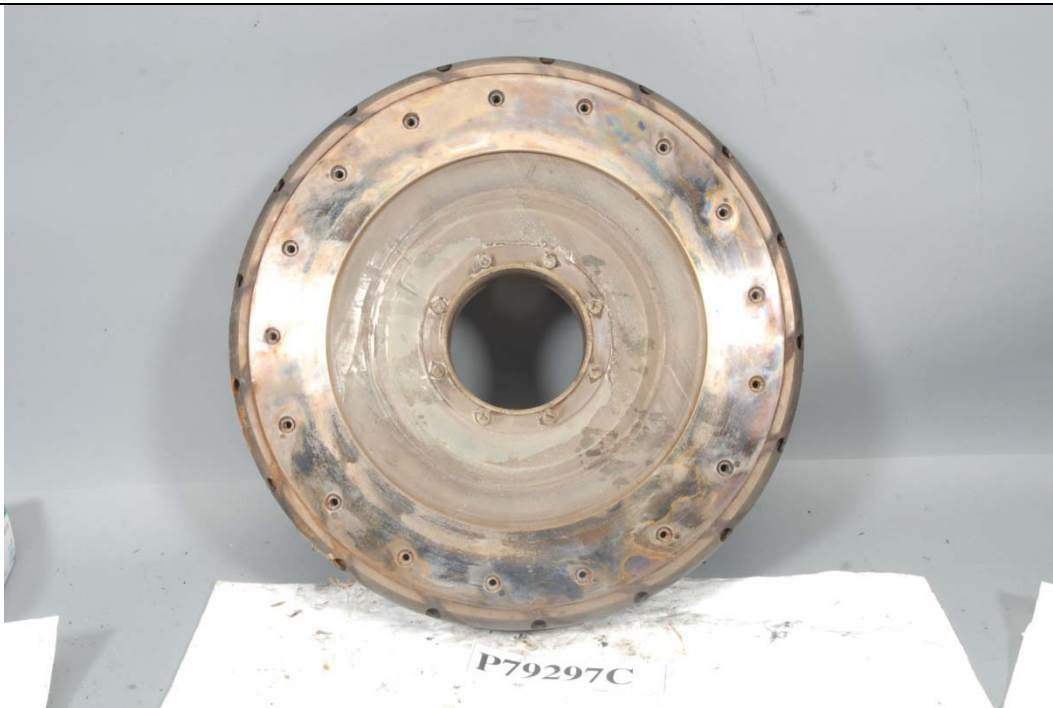


**Figure 126.** P-79297C, Combustor Chamber, Inner Skirt





**Figure 127.** P-79297C, Outer Transition Liner, ALF



**Figure 128.** P-79297C, Outer Transition Liner, FLA



**Figure 129.** P-79297C, Center Curvic Coupling



**Figure 130.** P-79297C, Center Curvic Coupling, Forward Curvic



**Figure 131. P-79297C, Center Curvic Coupling, Aft Curvic**



**Figure 132. P-79297C, First-Stage Turbine Stator Assembly, FLA**





**Figure 133. P-79297C, First-Stage Turbine Stator Assembly, ALF**



**Figure 134. P-79297C, First-Stage Turbine Stator Assembly, Stator Vanes**



**Figure 135.** P-79297C, First-Stage Turbine Stator Assembly

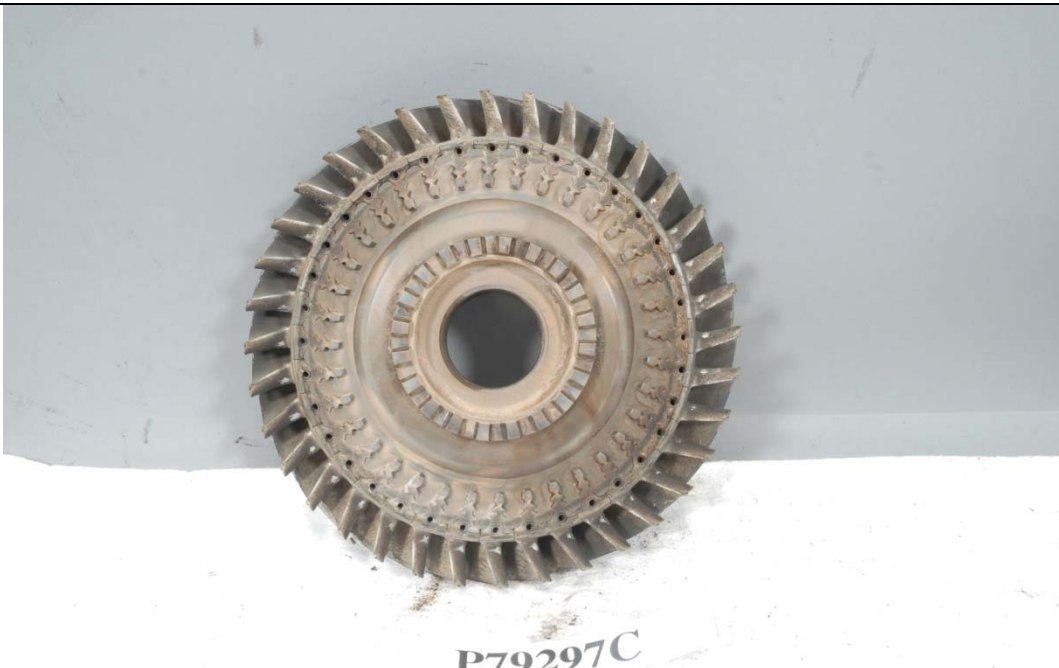


**Figure 136.** P-79297C, First-Stage Turbine Stator Assembly, Earthen Debris





**Figure 137.** P-79297C, First-Stage Turbine Stator Assembly, Rotational Scoring on First-Stage Turbine Shroud



**Figure 138.** P-79297C, First-Stage Turbine Rotor, FLA





*P79297C*

**Figure 139.** P-79297C, First-Stage Turbine Rotor, ALF



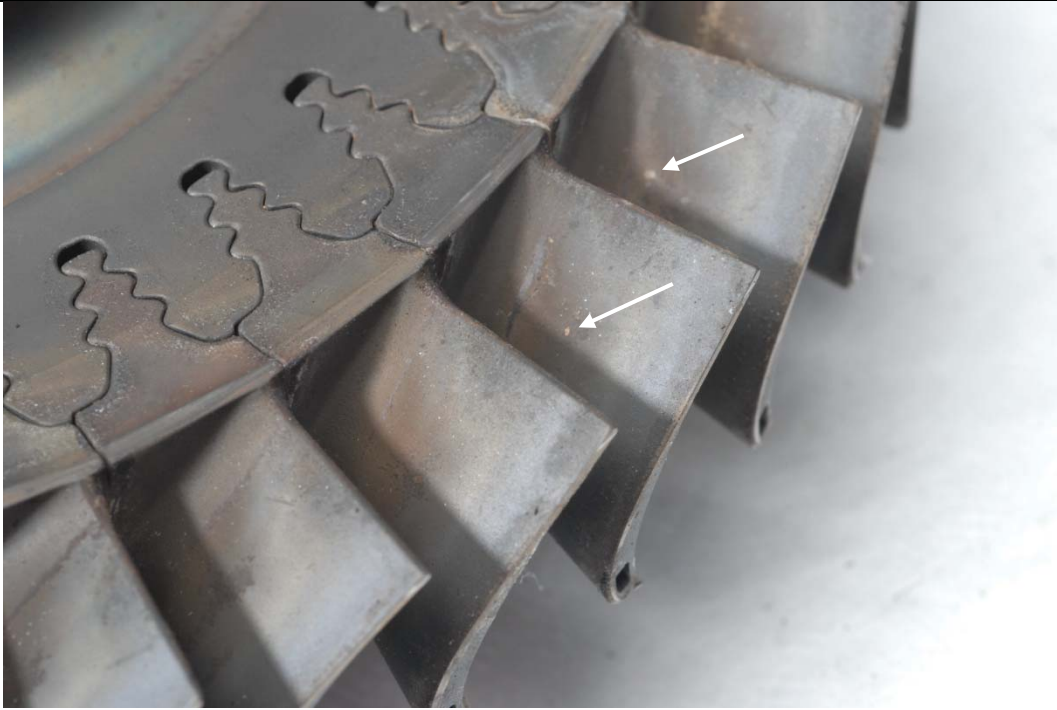
**Figure 140.** P-79297C, First-Stage Turbine Rotor



**Figure 141.** P-79297C, First-Stage Turbine Rotor



**Figure 142.** P-79297C, First-Stage Turbine Rotor



**Figure 143.** P-79297C, First-Stage Turbine Rotor, Metal Spray Deposits



**Figure 144.** P-79297C, First-Stage Turbine Rotor, Metal Spray Deposits





**Figure 145.** P-79297C, Second-Stage Turbine Stator, FLA



**Figure 146.** P-79297C, Second-Stage Turbine Stator, ALF



**Figure 147. P-79297C, Second-Stage Turbine Stator, Metal Spray Deposits**



**Figure 148. P-79297C, Second-Stage Turbine Stator, Rotational Scoring**



**Figure 149.** P-79297C, Second-Stage Turbine Rotor, FLA

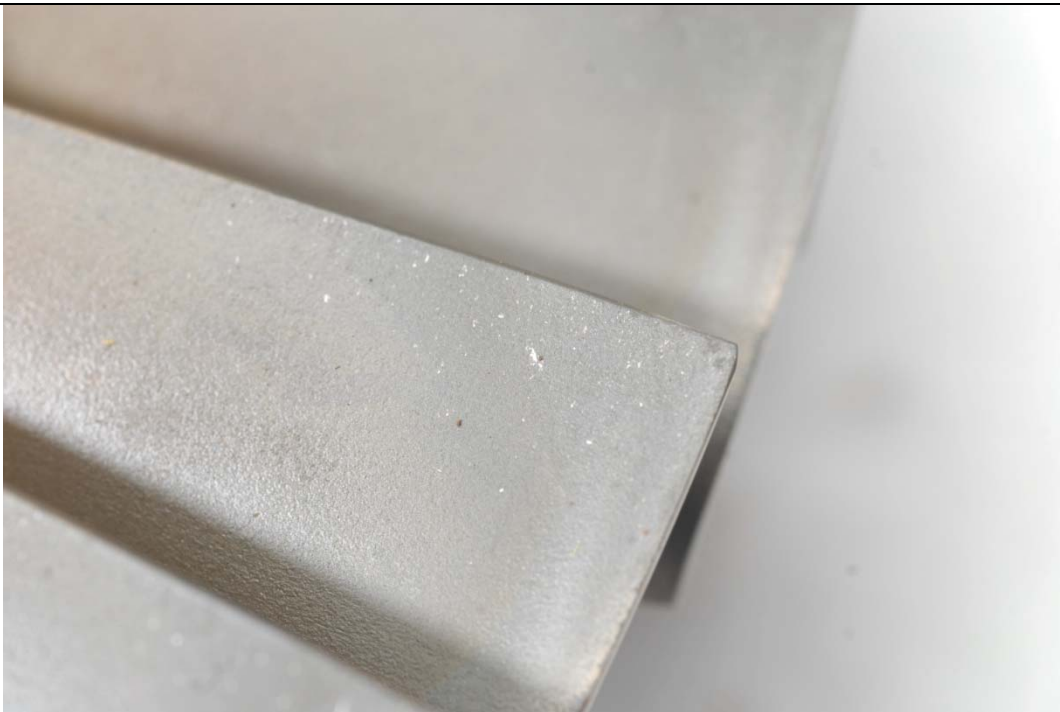


**Figure 150.** P-79297C, Second-Stage Turbine Rotor, ALF





**Figure 151.** P-79297C, Second-Stage Turbine Rotor



**Figure 152.** P-79297C, Second-Stage Turbine Rotor, Metal Spray Deposits



**Figure 153.** P-79297C, Second-Stage Turbine Rotor, Metal Spray Deposits



**Figure 154.** P-79297C, Third-Stage Turbine Stator, FLA



**Figure 155.** P-79297C, Third-Stage Turbine Stator, ALF



**Figure 156.** P-79297C, Third-Stage Turbine Stator, FLA





**Figure 157.** P-79297C, Third-Stage Turbine Stator, Rotational Scoring



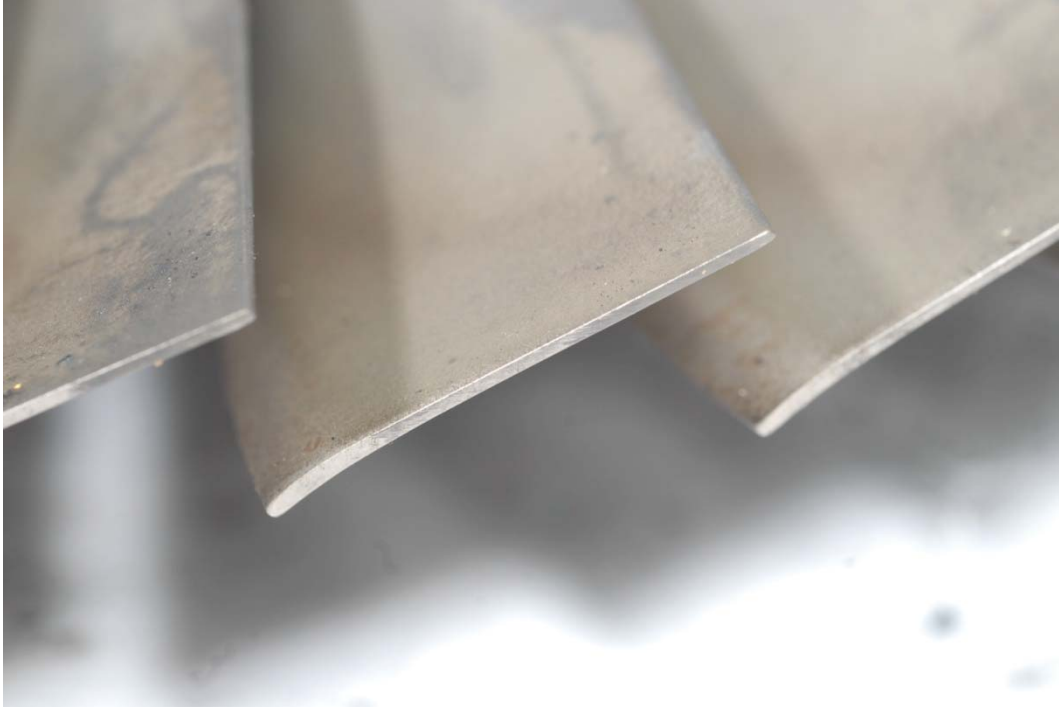
**Figure 158.** P-79297C, Third-Stage Turbine Stator, Metal Spray Deposits



**Figure 159.** P-79297C, Third-Stage Turbine Rotor, FLA



**Figure 160.** P-79297C, Third-Stage Turbine Rotor, ALF



**Figure 161. P-79297C, Third-Stage Turbine Rotor**



**Figure 162. P-79297C, Third-Stage Turbine Rotor, Metal Spray Deposits**





**Figure 163. P-79297C, Rear Curvic Coupling, FLA**



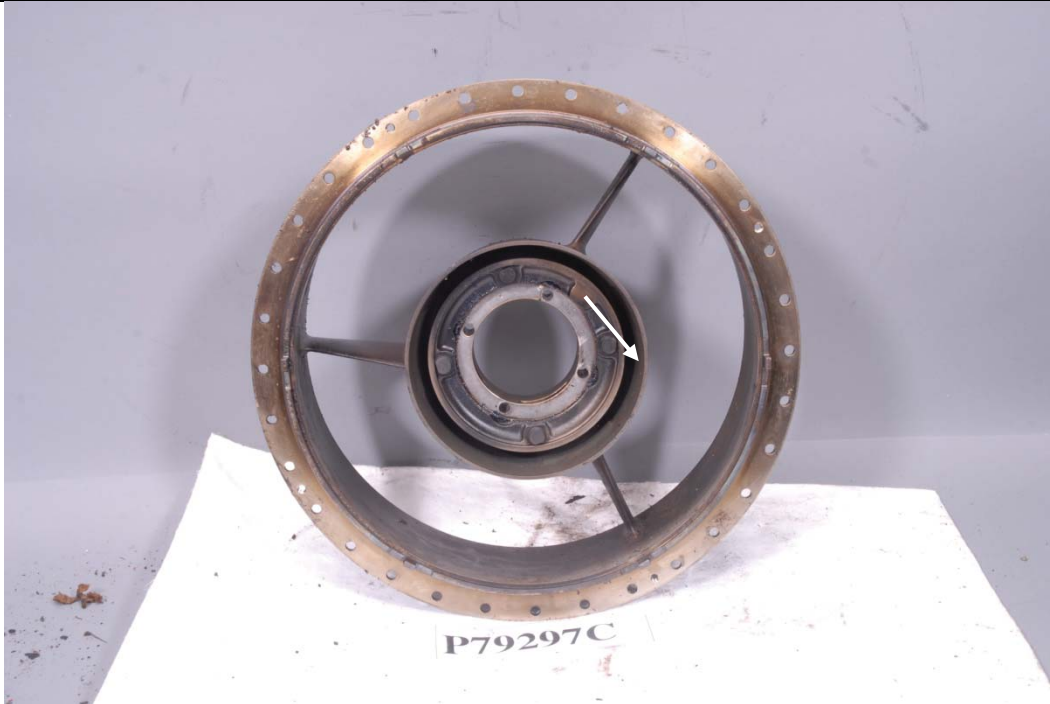
**Figure 164. P-79297C, Rear Curvic Coupling, ALF**



**Figure 165. P-79297C, Engine Exhaust Duct and Thermocouple Harness Assembly**



**Figure 166. P-79297C, Thermocouple Harness Assembly Impact Damage**



**Figure 167.** P-79297C, Turbine Bearing Support Housing, FLA



**Figure 168.** P-79297C, Turbine Bearing Support Housing, ALF

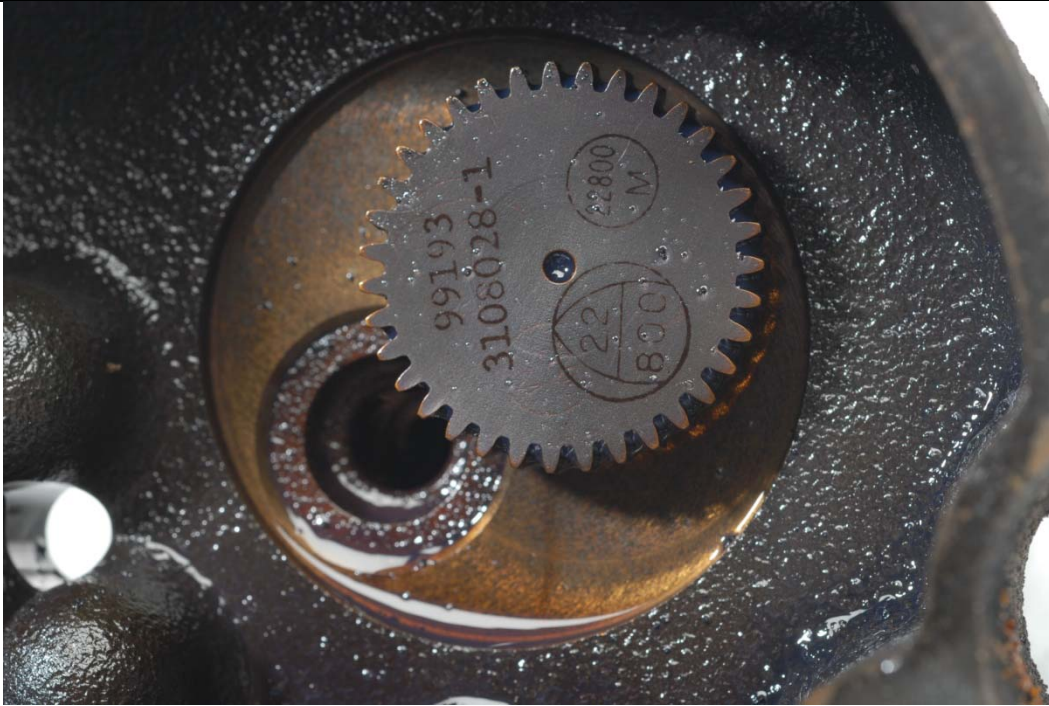




**Figure 169.** P-79297C, Turbine Oil-Scavenge Pump and Drive Shaft, FLA



**Figure 170.** P-79297C, Turbine Oil-Scavenge Pump and Drive Shaft, ALF



**Figure 171.** P-79297C, Turbine Oil-Scavenge Pump Element Drive Gear



**Figure 172.** P-79297C, Turbine Oil Inlet Tube



**Figure 173. P-79297C, Turbine Oil Inlet Jet**



**Figure 174. P-79297C, Turbine Oil Inlet Jet**





**Figure 175.** P-79297C, Turbine Air/Oil Carbon Seal



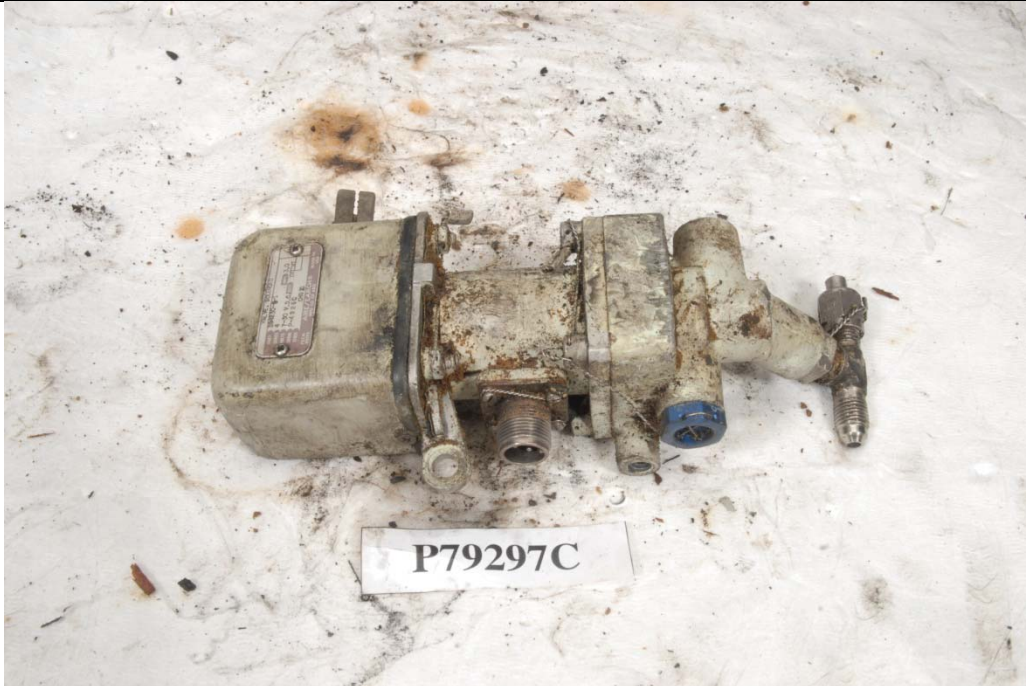
**Figure 176.** P-79297C, Turbine Air/Oil Carbon Seal



**Figure 177.** P-79297C, Turbine Bearing



**Figure 178.** P-79297C, Aft (Turbine) Main-Shaft Nut



**Figure 179. P-79297C, Manual Fuel Shutoff Valve**

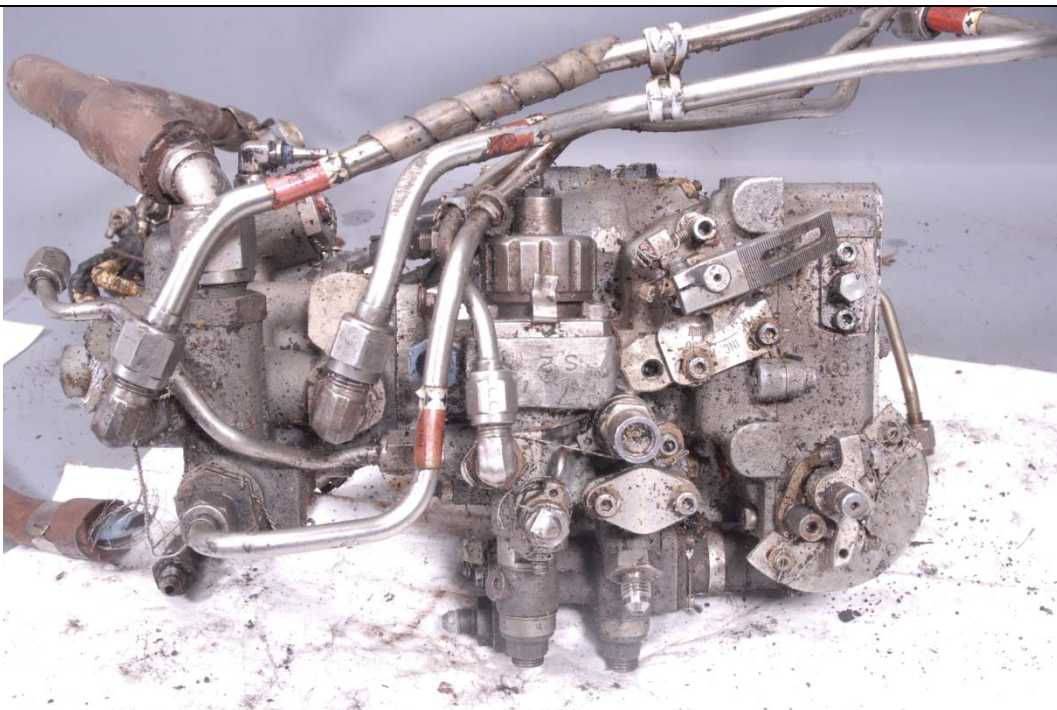


**Figure 180. P-79297C, Manual Fuel Shutoff Valve**

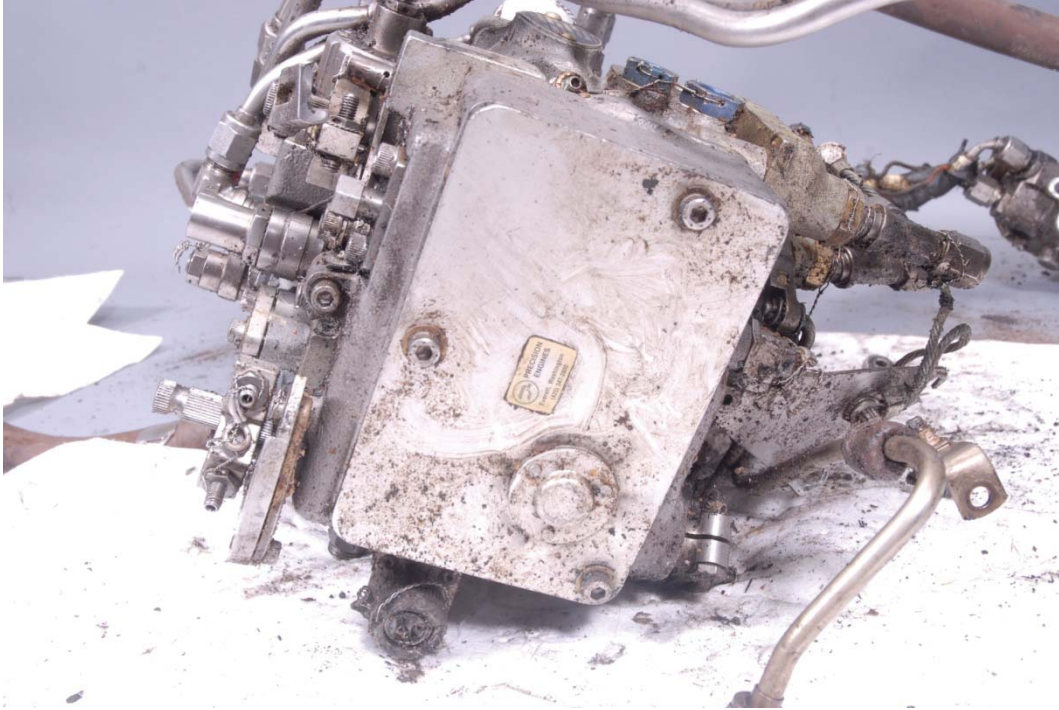




**Figure 181. P-79297C, Fuel Pump Assembly**



**Figure 182. P-79297C, Fuel Control**



**Figure 183.** P-79297C, Fuel Control

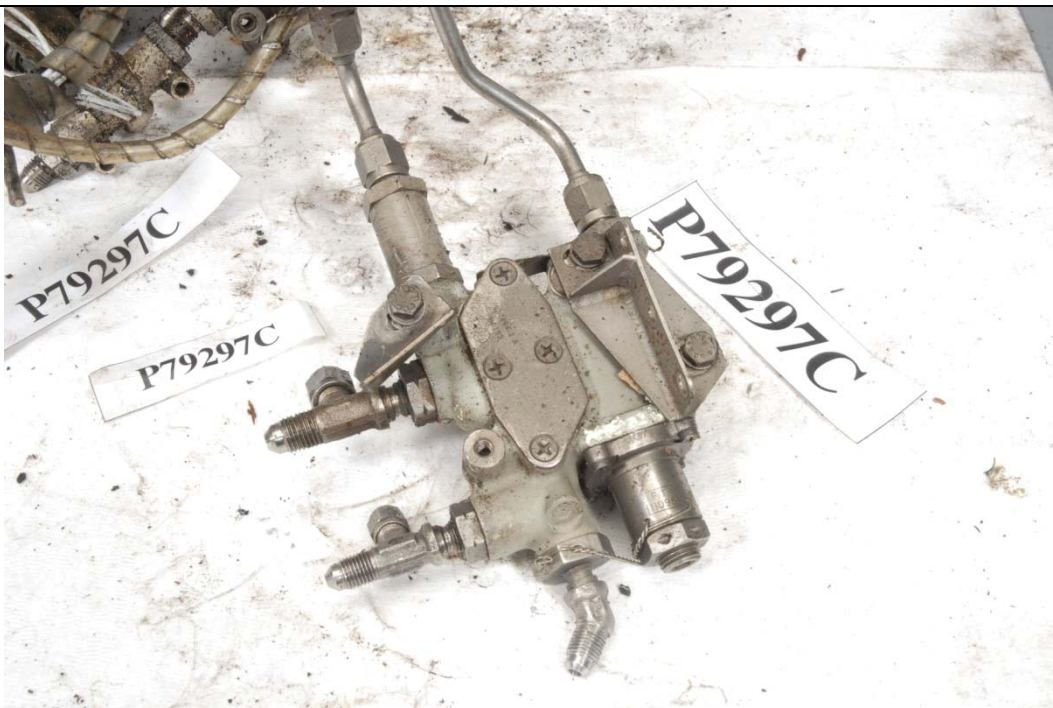


**Figure 184.** P-79297C, Fuel Control, Underspeed Governor Input Shaft Lever





**Figure 185. P-79297C, Fuel Filter**

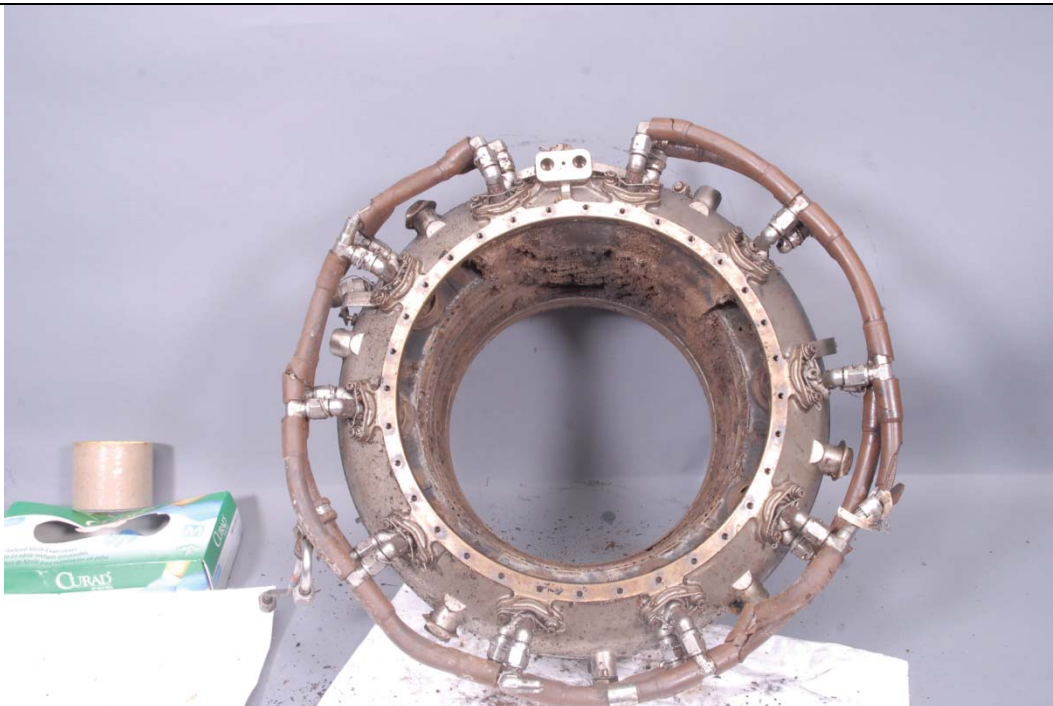


**Figure 186. P-79297C, Fuel Flow Divider**

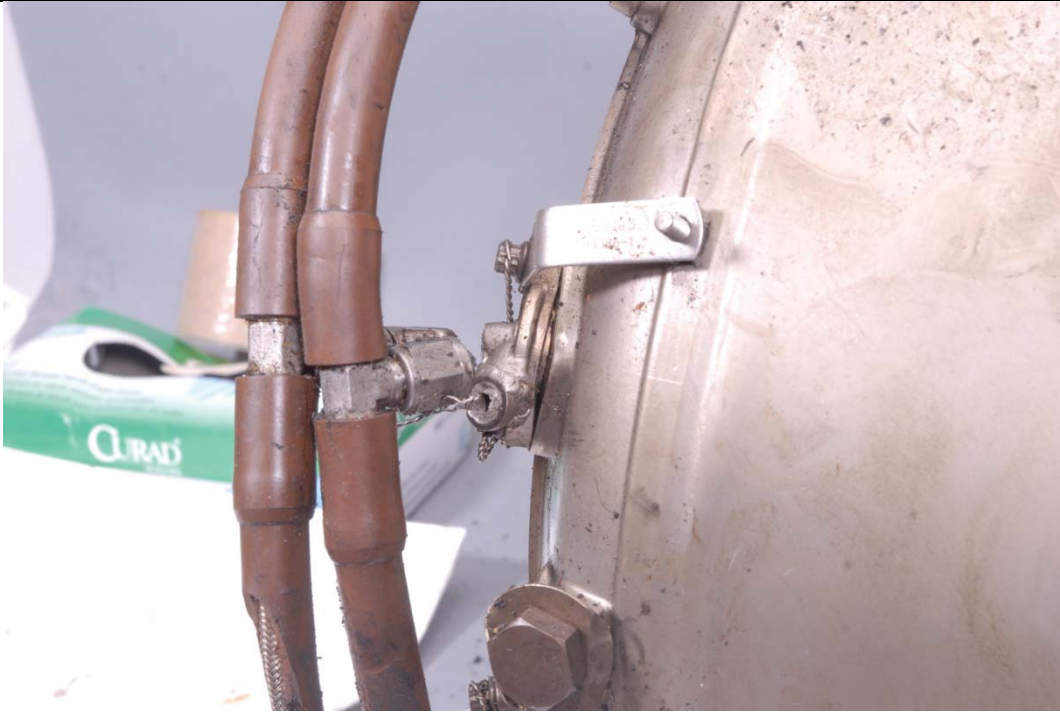




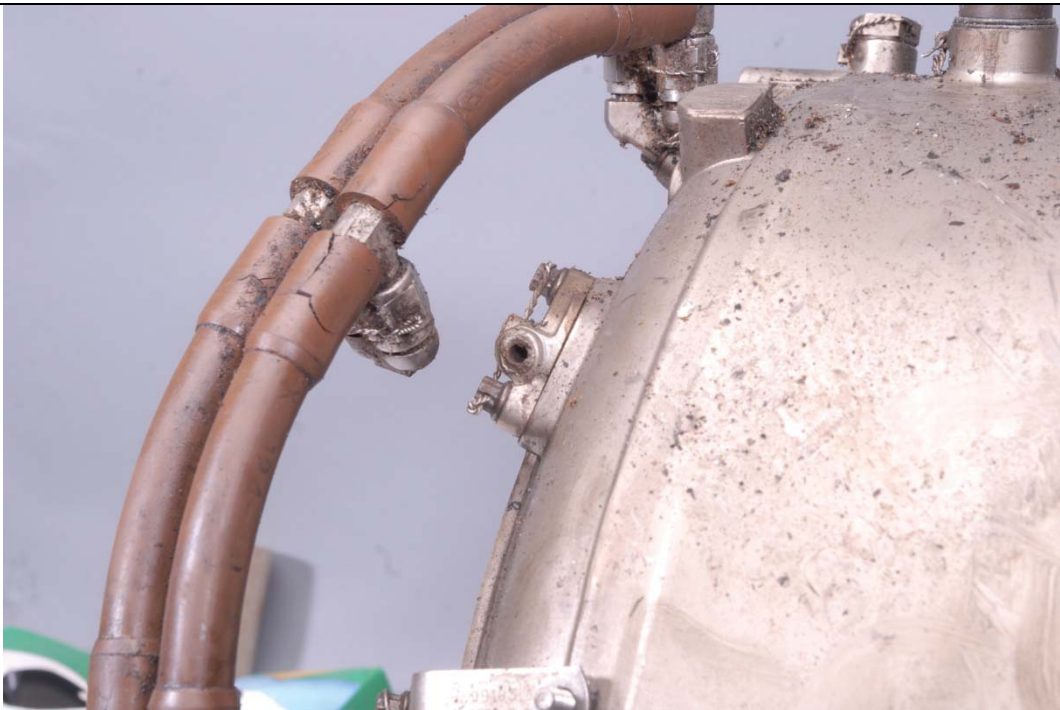
**Figure 187. P-79297C, Fuel Flow Divider**



**Figure 188. P-79297C, Fuel Manifold Hose Assembly**



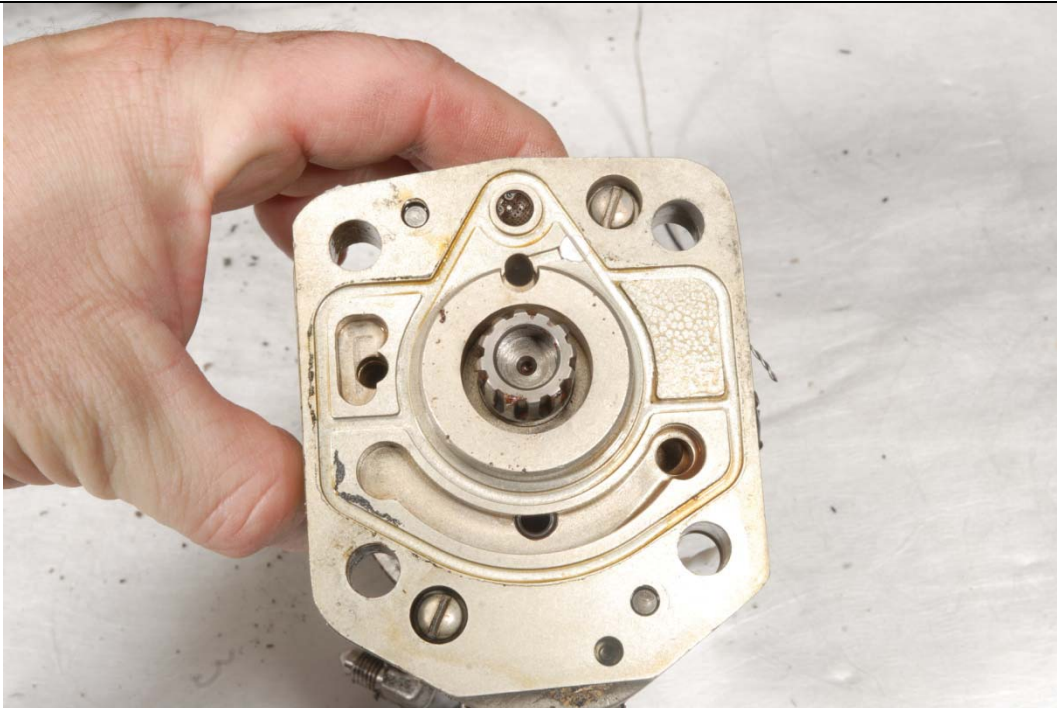
**Figure 189. P-79297C, Fuel Manifold Hose Assembly**



**Figure 190. P-79297C, Fuel Manifold Hose Assembly**



**Figure 191. P-79297C, Propeller Governor**



**Figure 192. P-79297C, Propeller Governor**





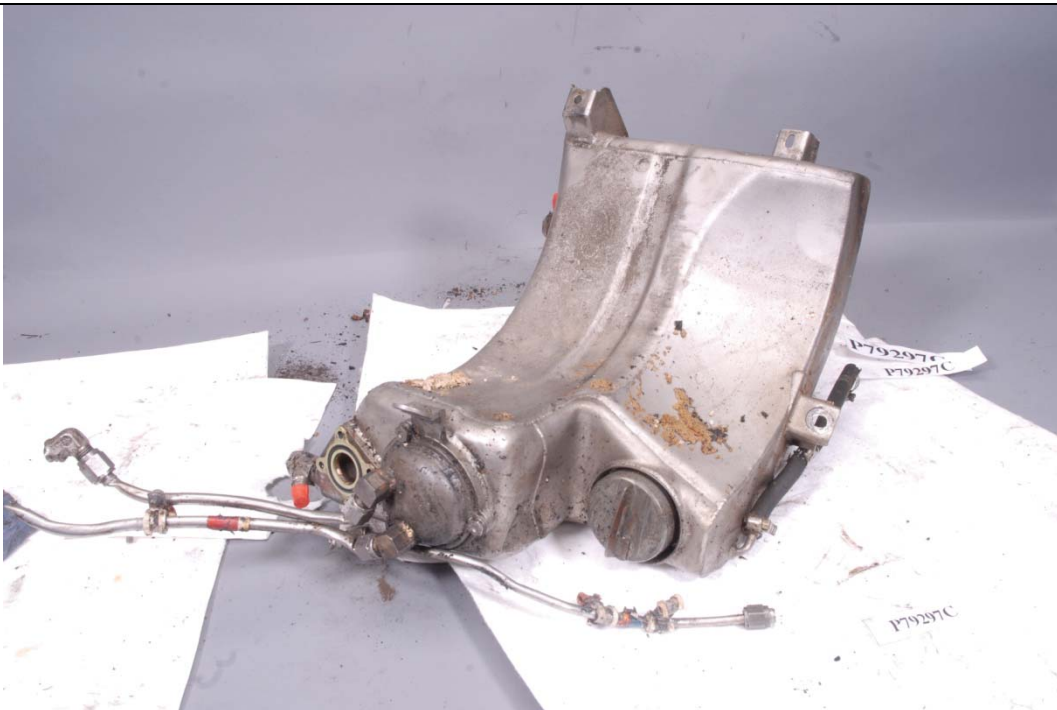
**Figure 193.** P-79297C, Propeller Pitch Control



**Figure 194.** P-79297C, Propeller Pitch Control



**Figure 195. P-79297C, Oil Filter**



**Figure 196. P-79297C, Oil Tank**





Figure 197. P-79297C, Oil Tank



Figure 198. P-79297C, Ignition Exciter





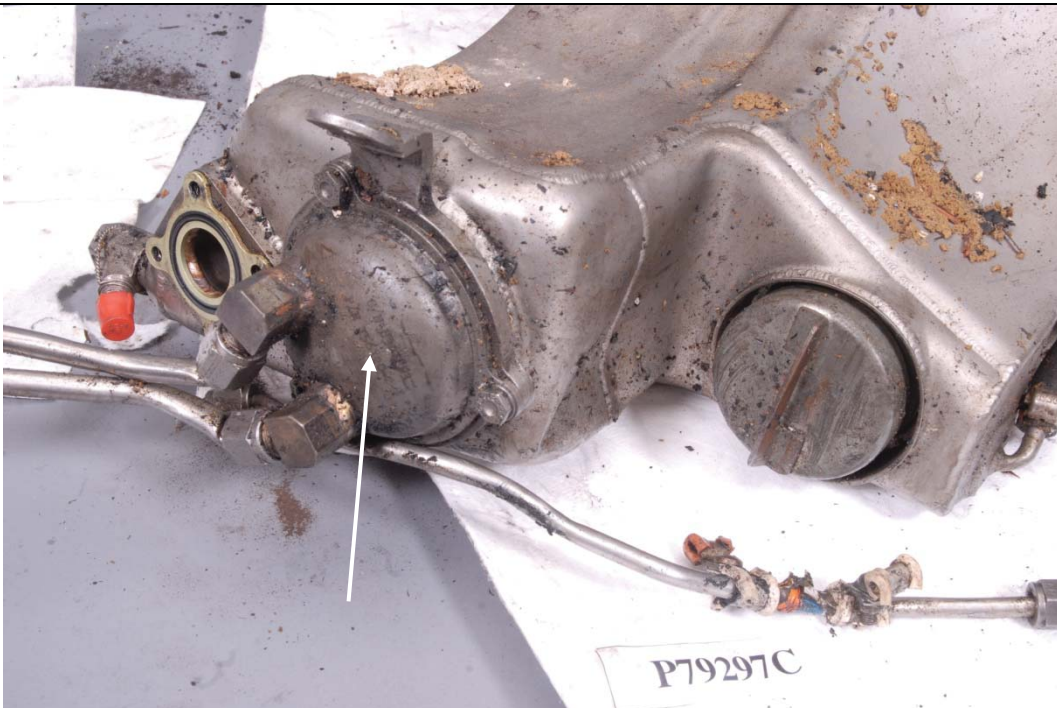
**Figure 199.** P-79297C, Ignition Exciter



**Figure 200.** P-79297C, Exciter to Igniter Lead Assembly

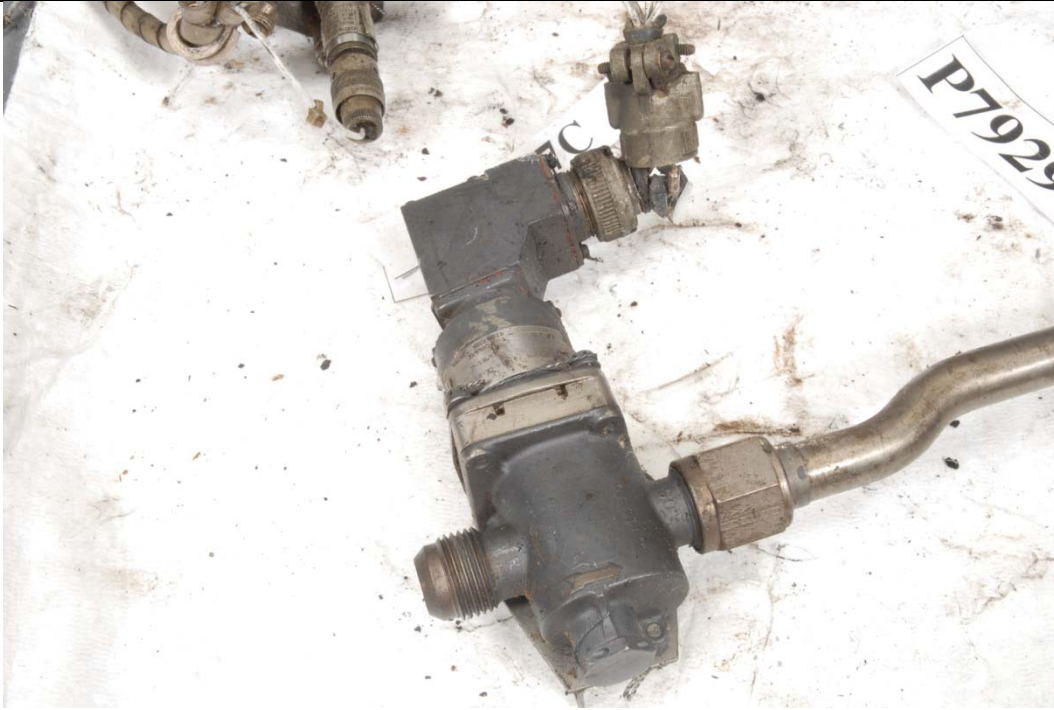


**Figure 201. P-79297C, Igniter**

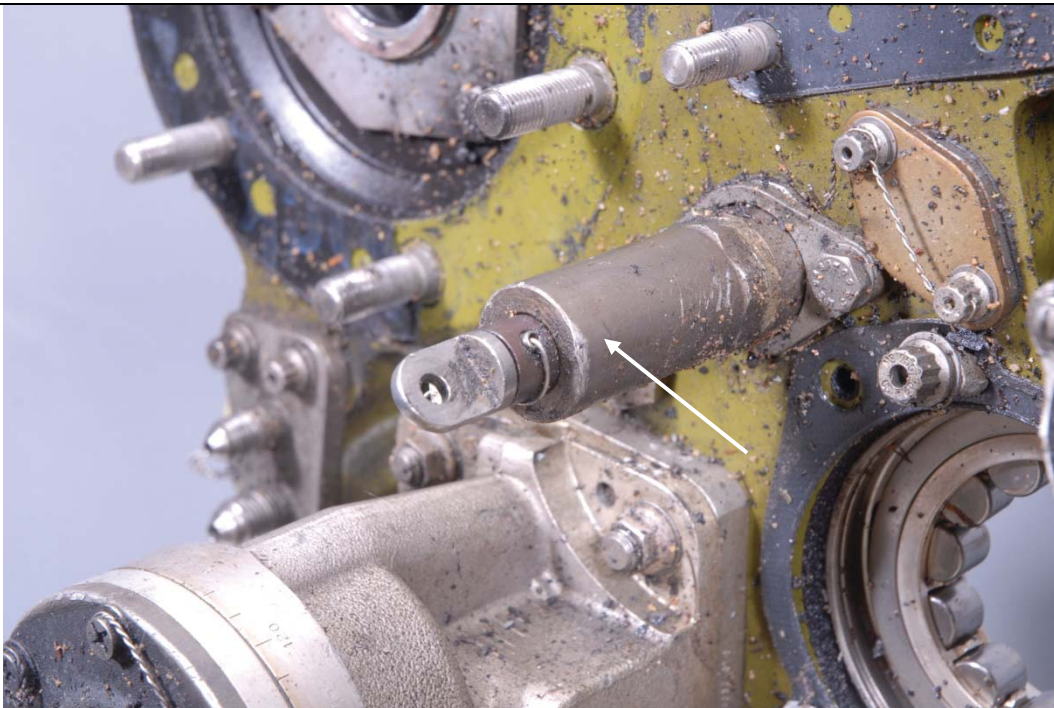


**Figure 202. P-79297C, Oil to Fuel Heater**





**Figure 203.** P-79297C, Anti-Ice Valve

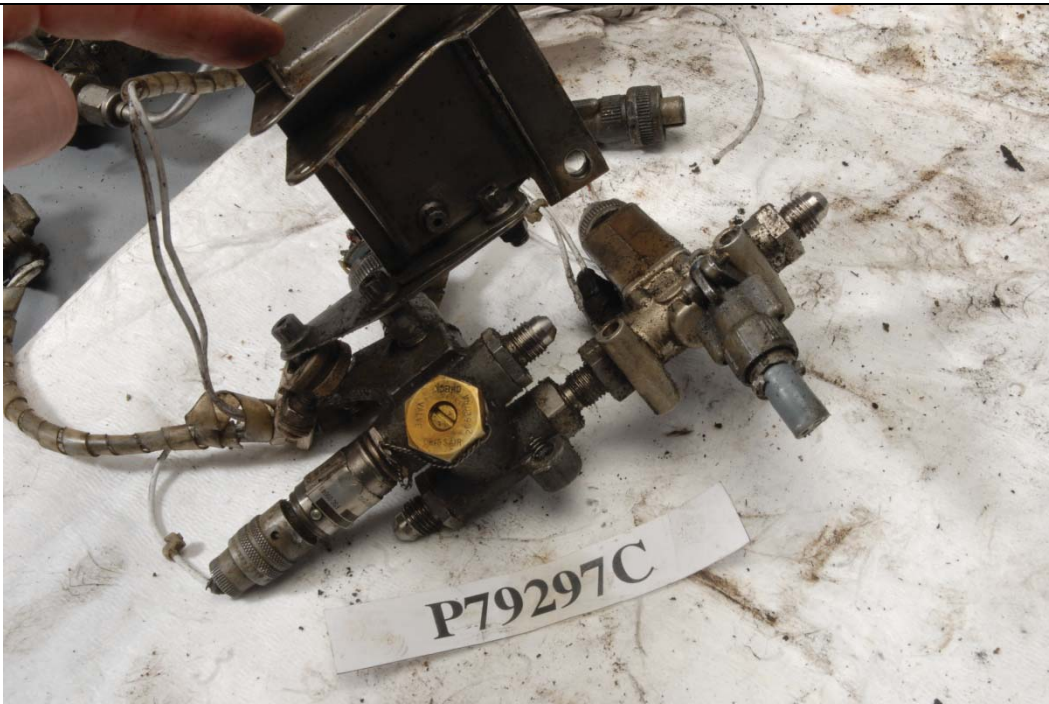


**Figure 204.** P-79297C, Feather Valve

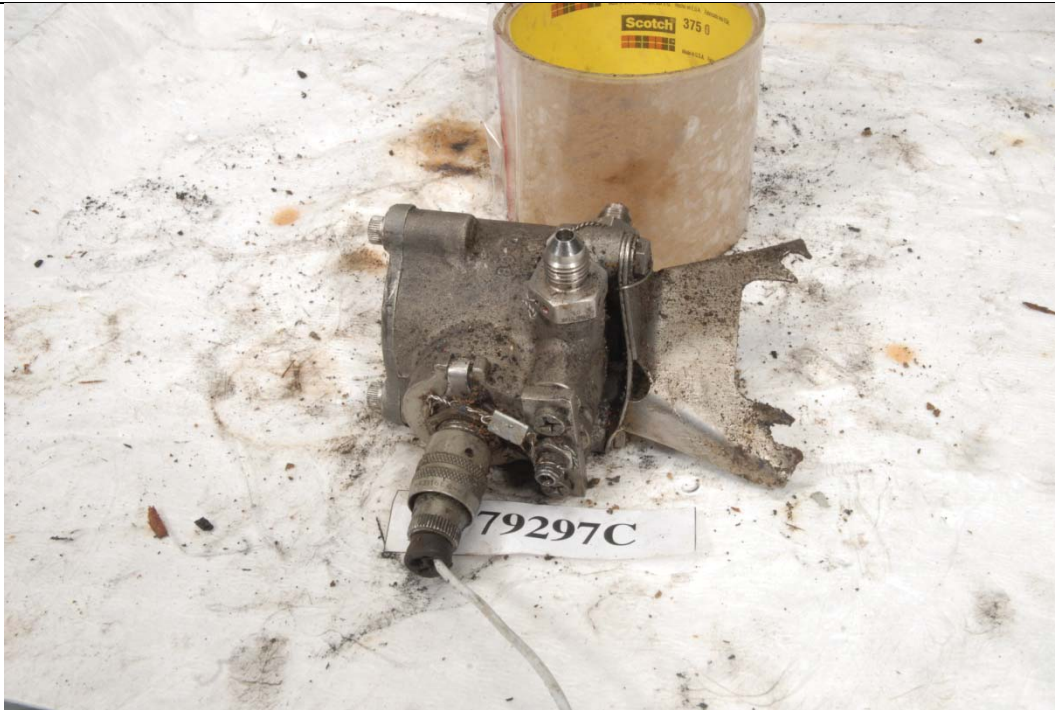




**Figure 205.** P-79297C, P2T2 Inlet Sensor



**Figure 206.** P-79297C, Beta and Negative Torque Sensing (NTS) Switch Manifold



**Figure 207. P-79297C, Torq/Temp Limiter (TTL) By-Pass Valve**



**Figure 208. P-79001C, As-Received**





Figure 209. P-79001C, As-Received



Figure 210. P-79001C, Dataplate





**Figure 211. P-79001C, As-Received, Left Side**



**Figure 212. P-79001C, As-Received, Right Side**





**Figure 213. P-79001C, Intermediate Case Fracture**

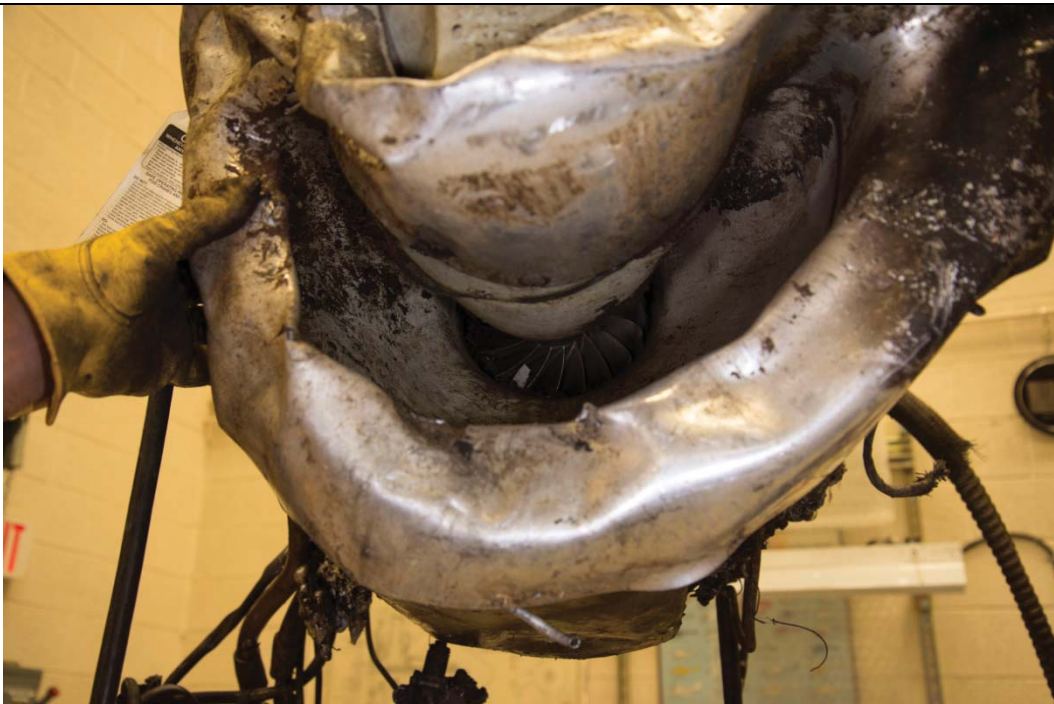


**Figure 214. P-79001C, Fire Damage**





**Figure 215. P-79001C, Impact Damage**



**Figure 216. P-79001C, Inlet Area**





**Figure 217.** P-79001C, Beta Tube



**Figure 218.** P-79001C, Upper Gearcase Mount



**Figure 219. P-79001C, Right Gearcase Mount**



**Figure 220. P-79001C, Left Gearcase Mount**





**Figure 221.** P-79001C, Aft Engine Mount



**Figure 222.** P-79001C, Fuel Pump/Fuel Control Separation





**Figure 223. P-79001C, Nose Cone Housing**



**Figure 224. P-79001C, Nose Cone Housing**



**Figure 225.** P-79001C, Propeller Shaft Mount Flange and Alignment Dowels



**Figure 226.** P-79001C, Forward Propeller Shaft Bearing Mount Bolts



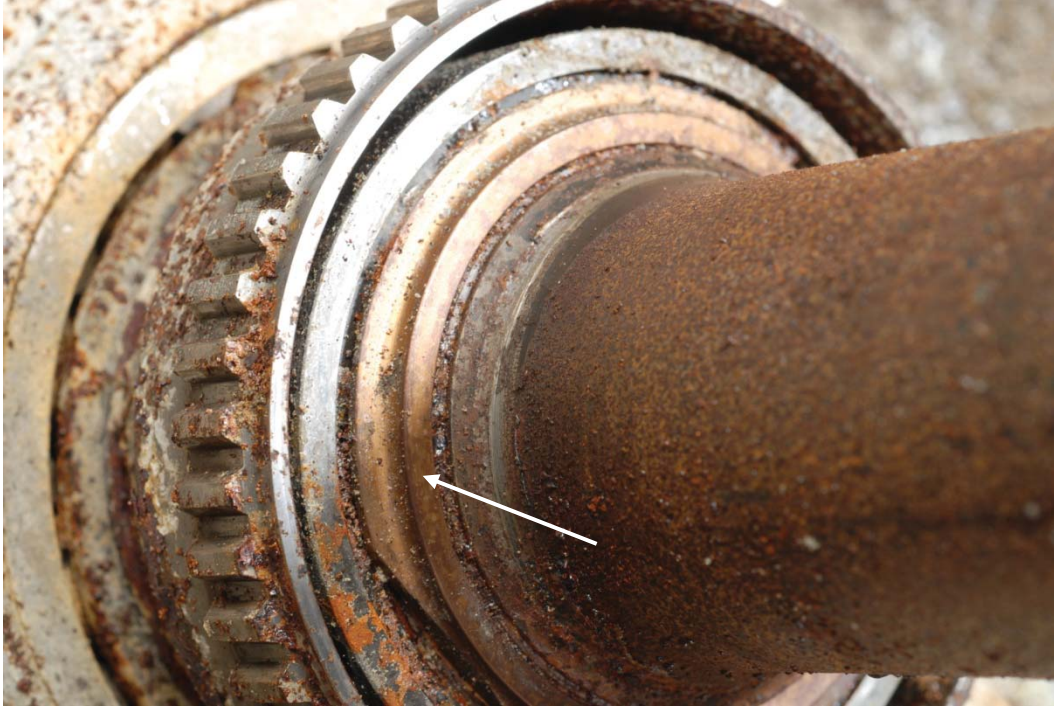


**Figure 227.** P-79001C, Propeller Shaft, Rotational Scoring



**Figure 228.** P-79001C, Propeller Shaft, Rotational Scoring





**Figure 229. P-79001C, Propeller Shaft Lock Nut**

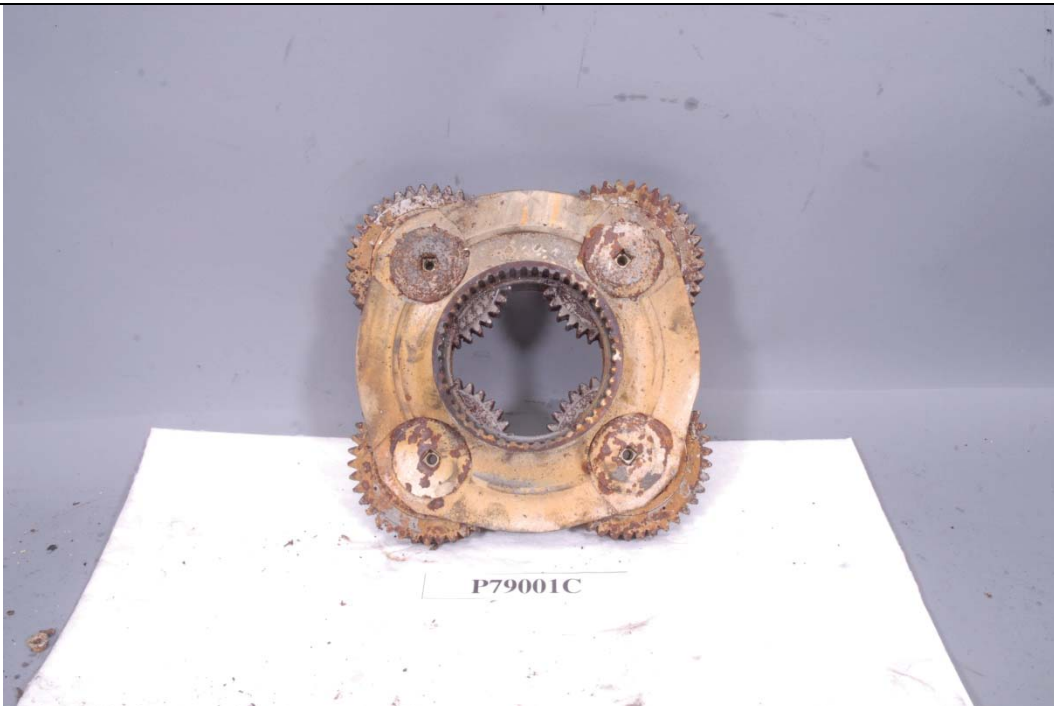


**Figure 230. P-79001C, The Propeller Shaft Bearing Oil Jet**





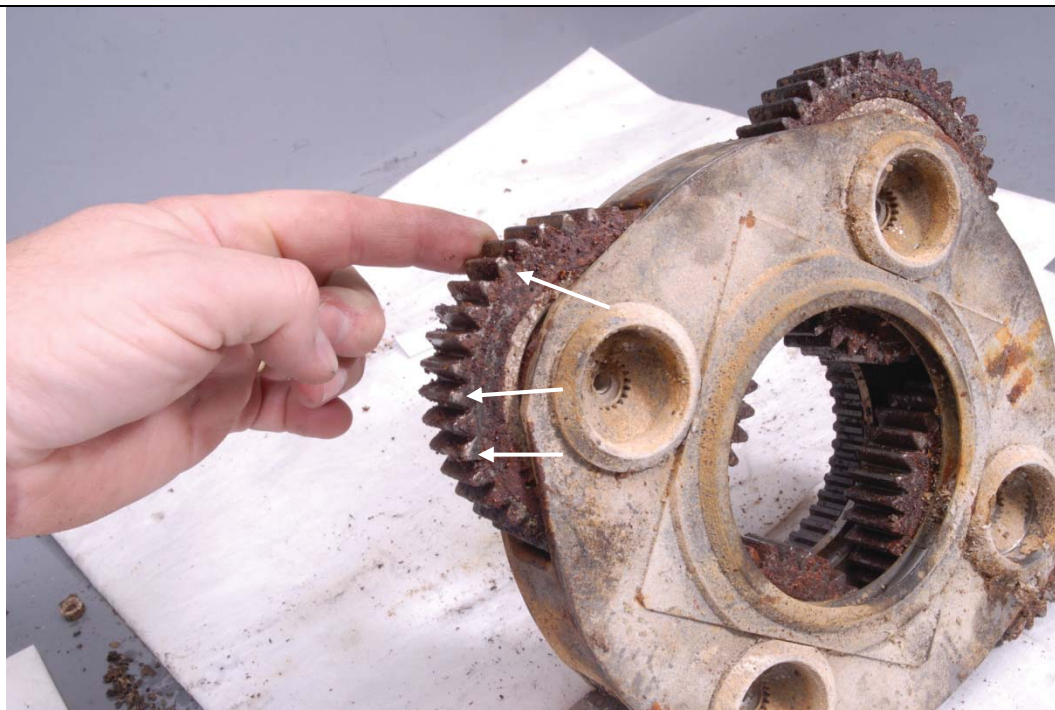
**Figure 231. P-79001C, Propeller Shaft Coupler**



**Figure 232. P-79001C, Planetary Gear Assembly, FLA**



**Figure 233.** P-79001C, Planetary Gear Assembly, ALF



**Figure 234.** P-79001C, Planetary Gear Assembly, Rotational Scoring





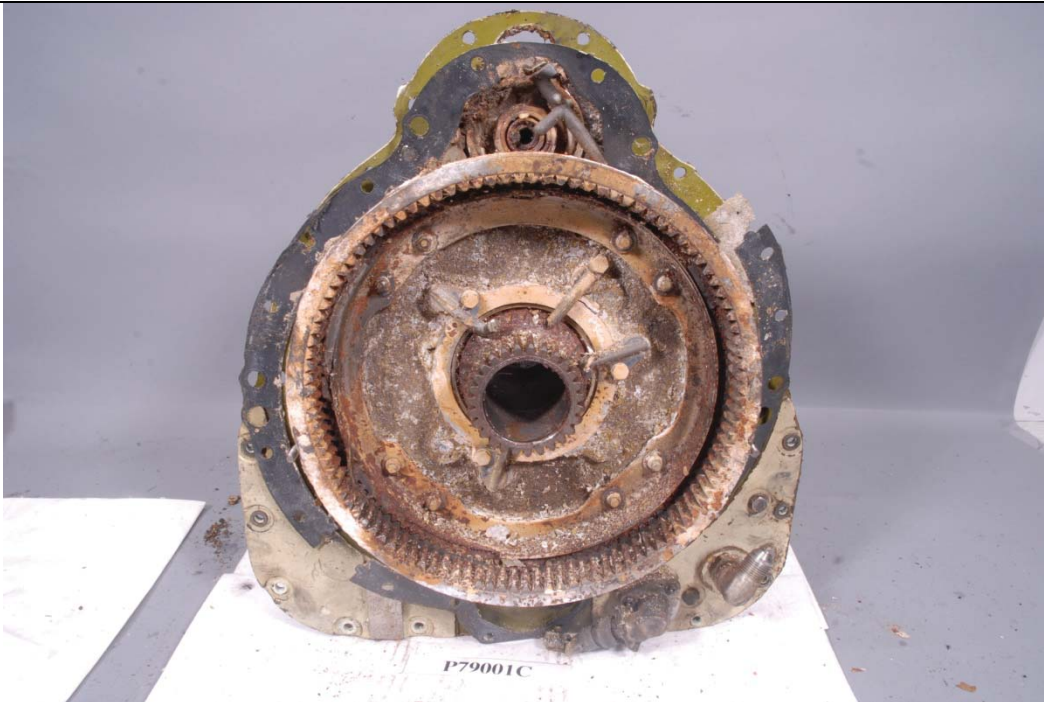
**Figure 235.** P-79001C, Ring Gear



**Figure 236.** P-79001C, Ring Gear Support, Fracture



**Figure 237.** P-79001C, Ring Gear Support, Fracture



**Figure 238.** P-79001C, Diaphragm Housing, FLA



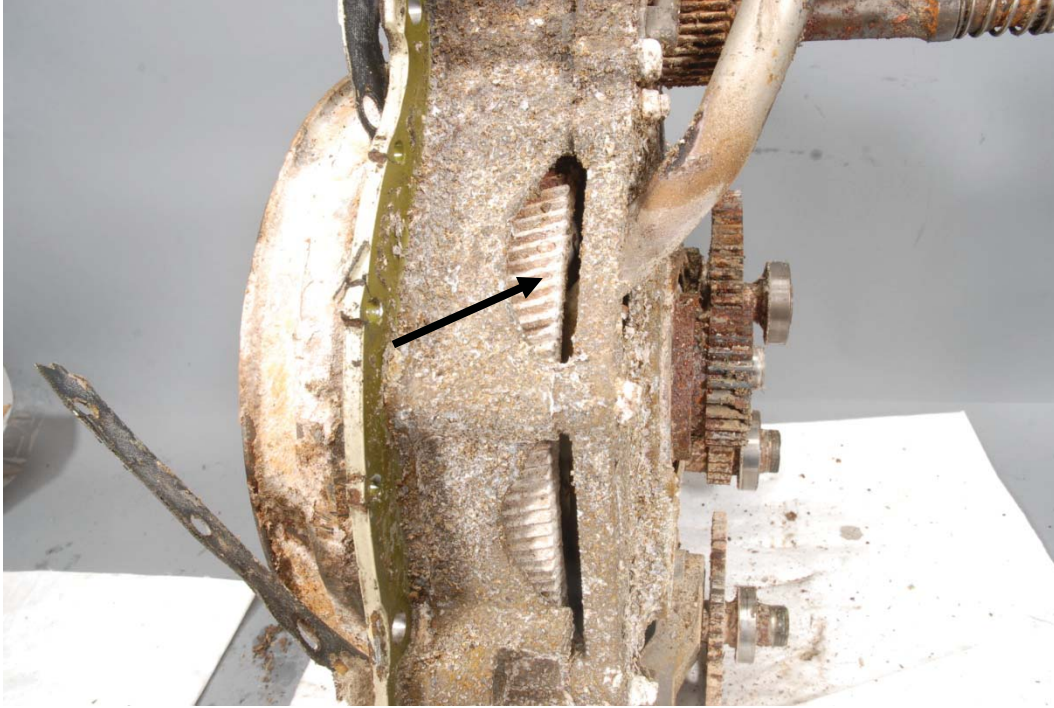


**Figure 239.** P-79001C, Diaphragm Housing, ALF



**Figure 240.** P-79001C, Diaphragm Housing, Bolt Hole Fractures





**Figure 241. P-79001C, Bull Gear**



**Figure 242. P-79001C, Aft Bull Gear Bearing**



**Figure 243.** P-79001C, Sun Gear



**Figure 244.** P-79001C, Forward Sun Gear, Rotational Scoring





**Figure 245.** P-79001C, Aft Sun Gear, Rotational Scoring



**Figure 246.** P-79001C, Aft Sun Gear, Rotational Scoring





**Figure 247. P-79001C, Bull/Sun Gear Nut, Rotational Scoring**



**Figure 248. P-79001C, High-Speed Pinion HSP**

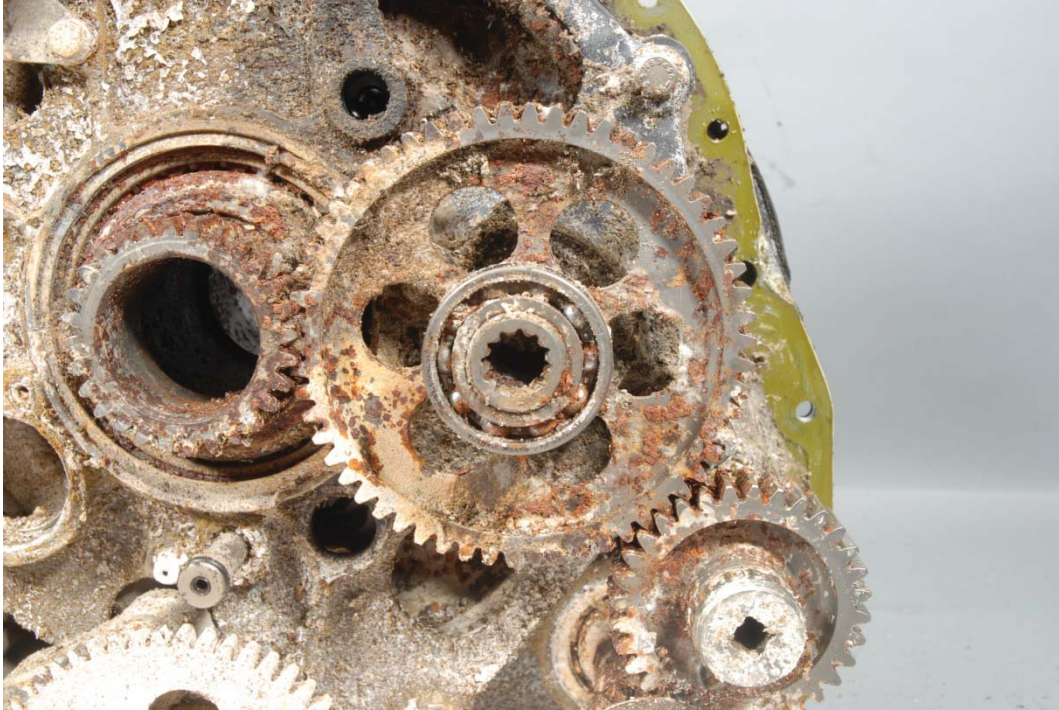




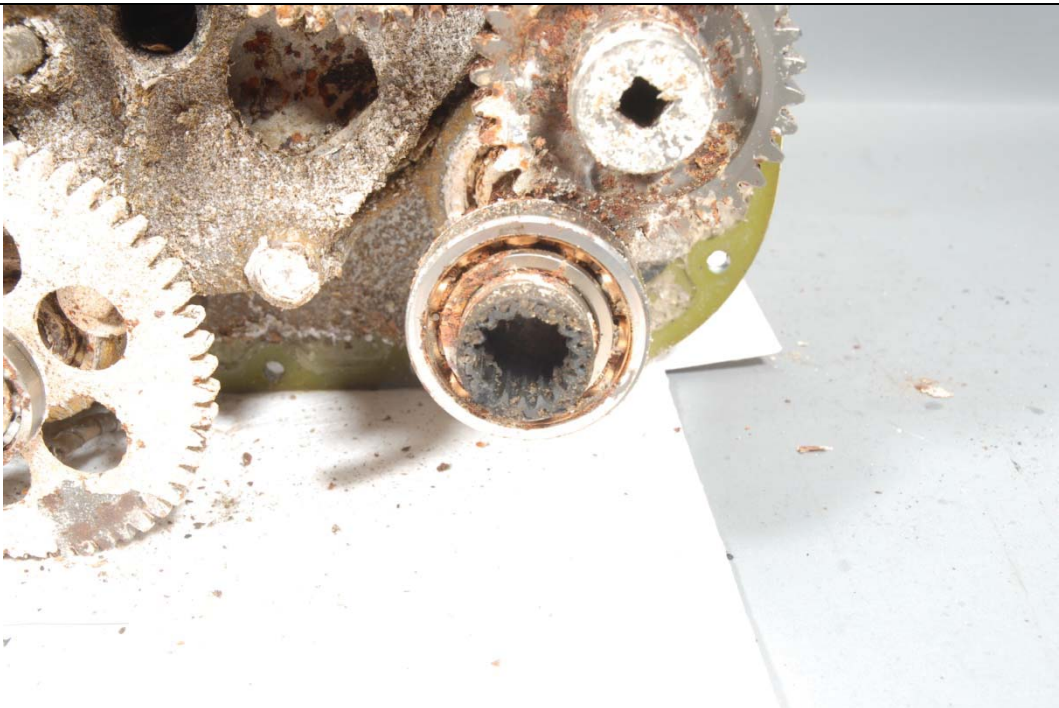
**Figure 249.** P-79001C, HSP-to-Power Section Coupling Shaft



**Figure 250.** P-79001C, Hydraulic Pump Drive Gearshaft Assembly

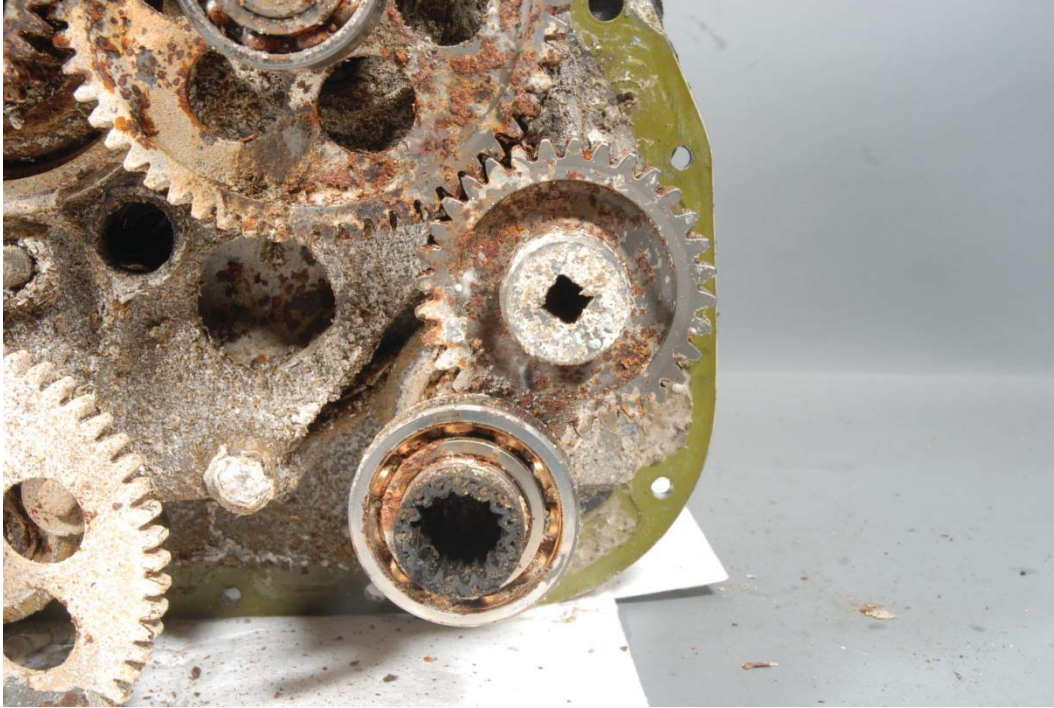


**Figure 251.** P-79001C, Propeller Governor Drive Gear Assembly

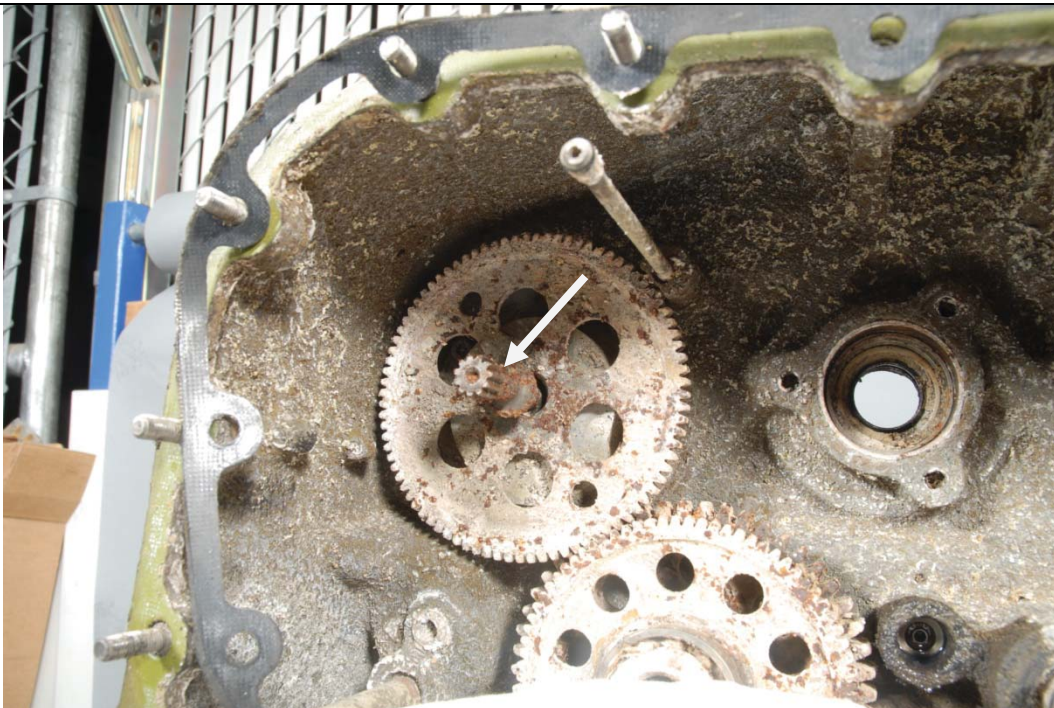


**Figure 252.** P-79001C, Starter/Generator Drive Gearshaft Assembly





**Figure 253.** P-79001C, Starter/Generator Idler Gear Assembly



**Figure 254.** P-79001C, Gearcase Oil-Scavenge Pump Drive Shaft

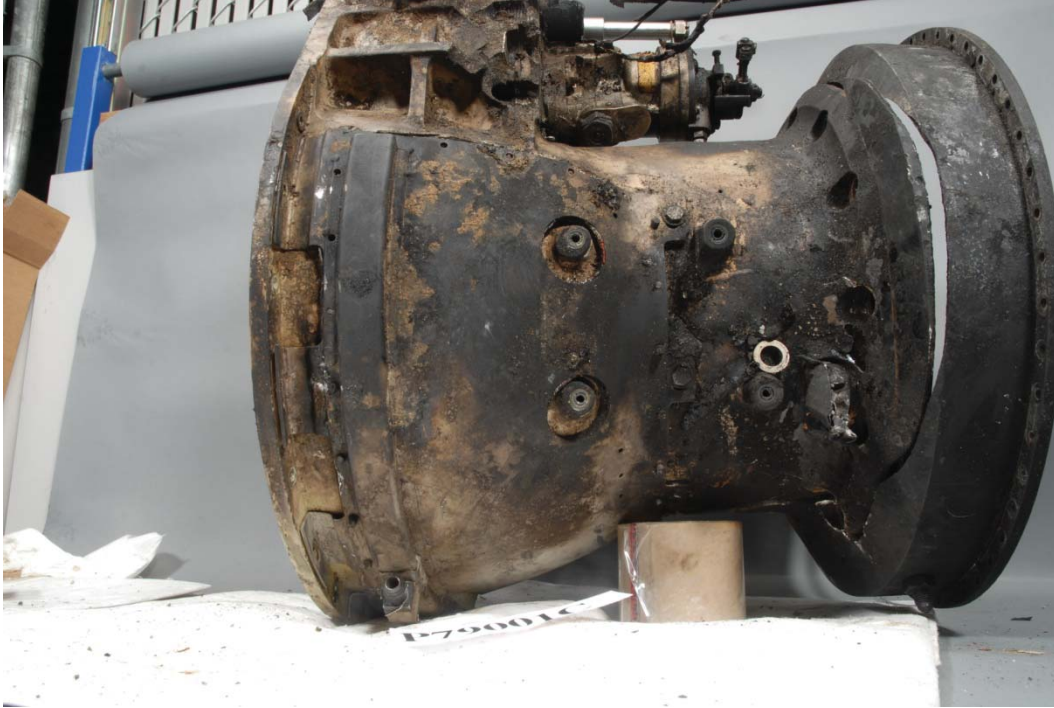


**Figure 255. P-79001C, Accessory Drive Housing (Gearcase)**



**Figure 256. P-79001C, Accessory Drive Housing (Gearcase)**





**Figure 257.** P-79001C, Anti-Ice Shield



**Figure 258.** P-79001C, Propeller Shaft Aft Ball Bearing





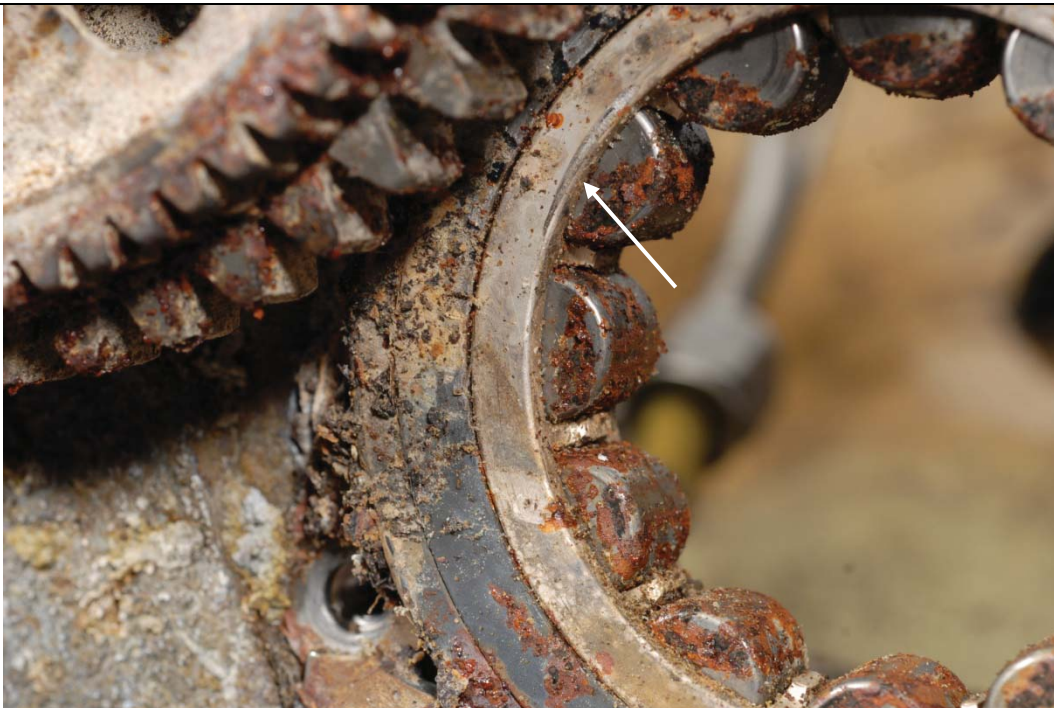
**Figure 259.** P-79001C, Propeller Shaft Aft Ball Bearing



**Figure 260.** P-79001C, Propeller Shaft Aft Roller Bearing, FLA



**Figure 261.** P-79001C, Propeller Shaft Aft Roller Bearing, Outer Race Fracture



**Figure 262.** P-79001C, Propeller Shaft Aft Roller Bearing, Rotational Scoring





**Figure 263.** P-79001C, Forward (Compressor) Main-Shaft Nut



**Figure 264.** P-79001C, Main Shaft DDFC Drive Gear





**Figure 265. P-79001C, Compressor Bearing**



**Figure 266. P-79001C, Compressor Air/Oil Carbon Seal**

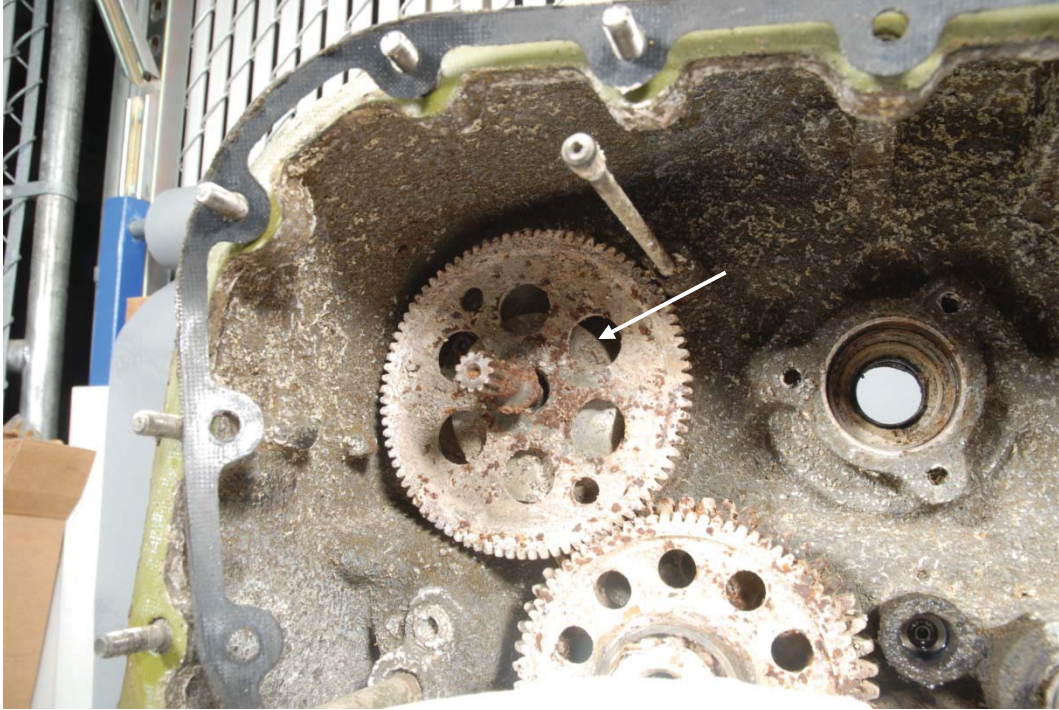


**Figure 267.** P-79001C, Fuel-Pump Drive Shaft

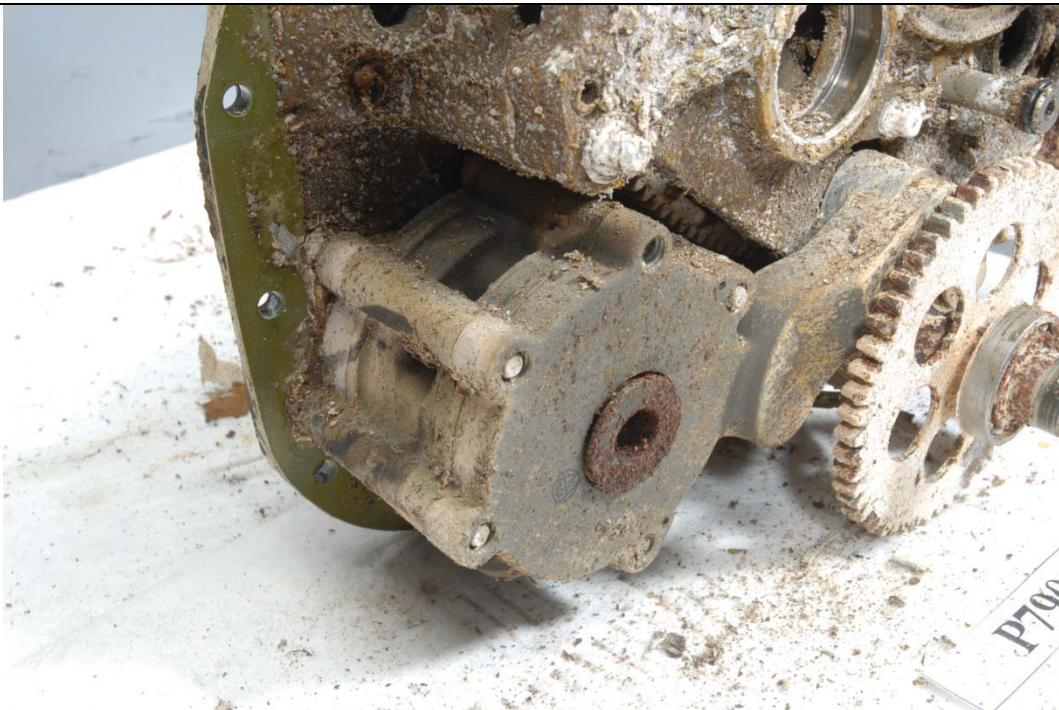


**Figure 268.** P-79001C, Magnetic Drain Plug (Chip Detector)





**Figure 269.** P-79001C, Oil Pressure Pump



**Figure 270.** P-79001C, Gearcase Oil-Scavenge Pump

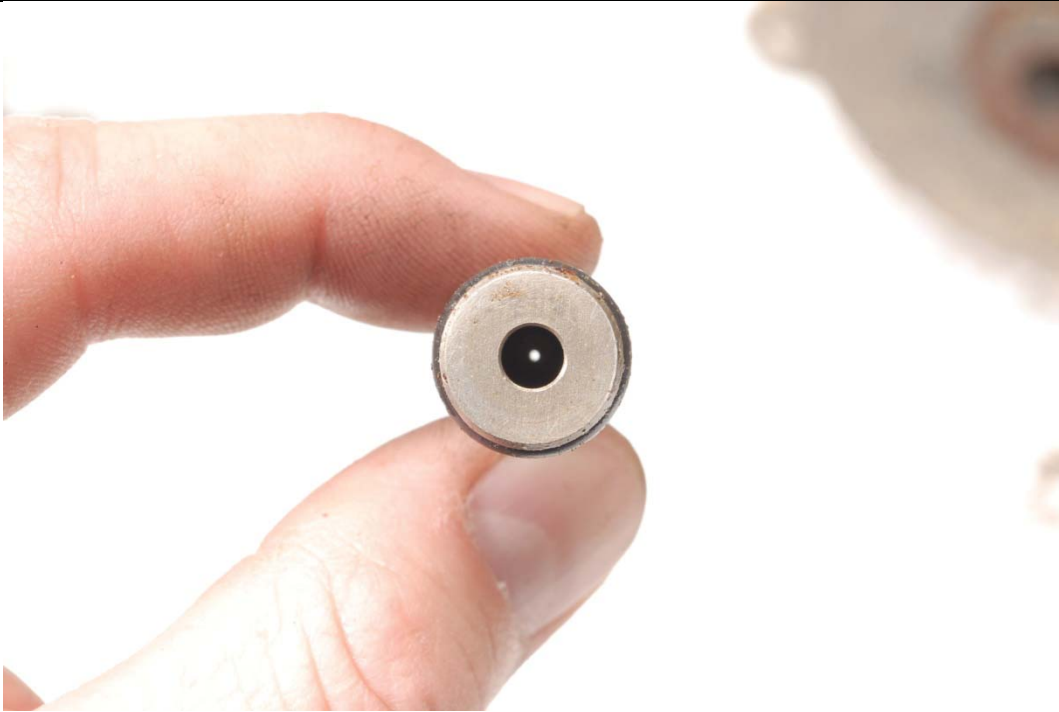




**Figure 271.** P-79001C, Negative Torque Sensing (NTS) Regulator



**Figure 272.** P-79001C, NTS Transfer Tube and Orifice Assembly

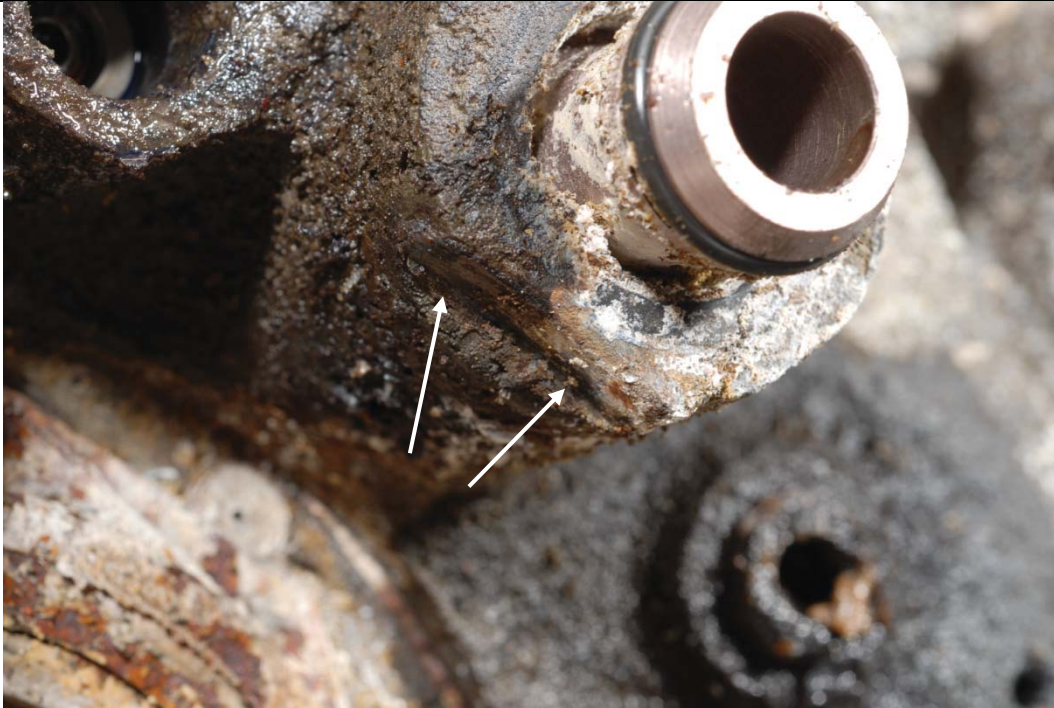


**Figure 273.** P-79001C, NTS Transfer Tube and Orifice Assembly



**Figure 274.** P-79001C, Feather Valve Oil Transfer Tube





**Figure 275.** P-79001C, Feather Valve Oil Transfer Tube Mount Boss, Impact Damage

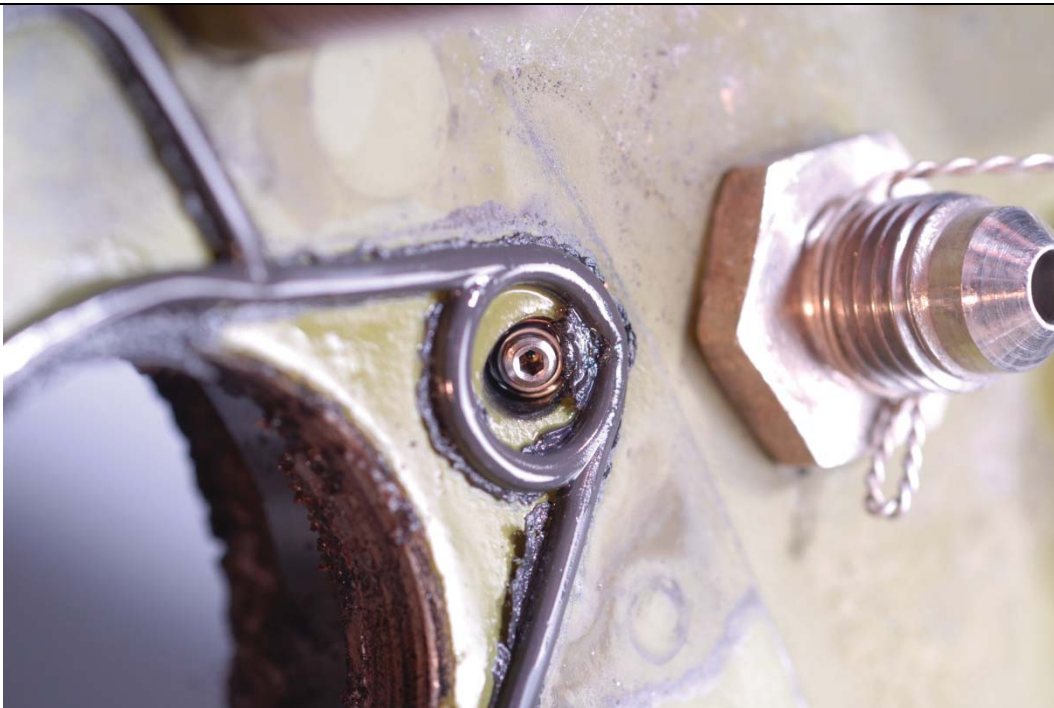


**Figure 276.** P-79001C, Oil Screen (Torque Sensor)





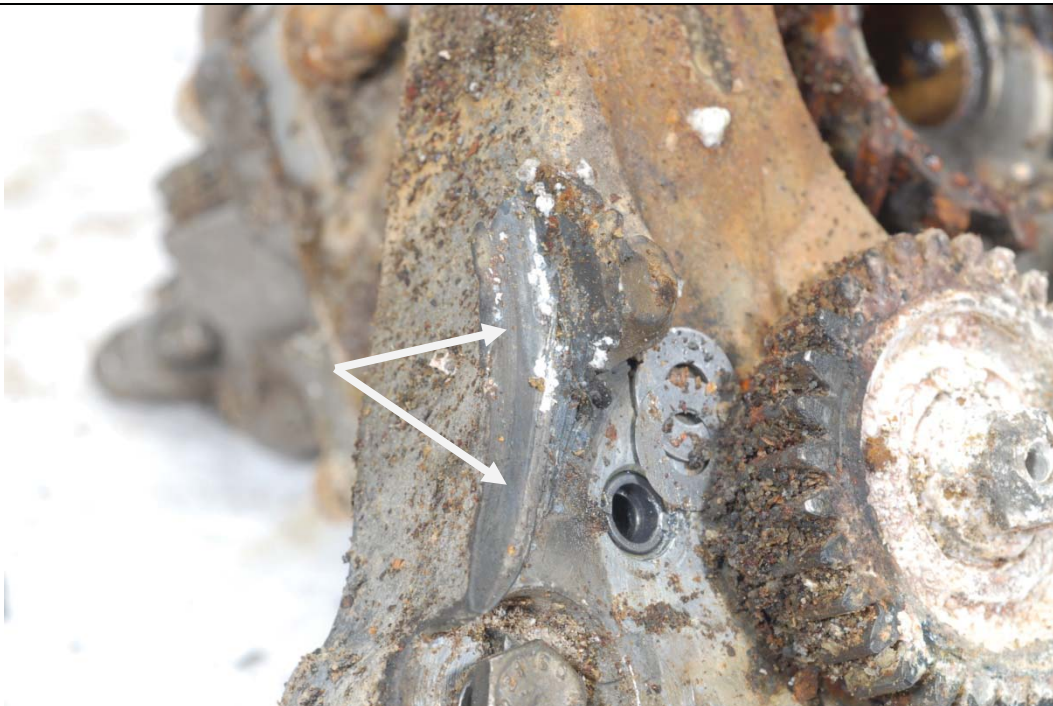
**Figure 277.** P-79001C, Propeller Governor “Spider” Gasket



**Figure 278.** P-79001C, Propeller Governor Reset Orifice



**Figure 279.** P-79001C, Torque Sensor



**Figure 280.** P-79001C, Torque Sensor, Rotational Scoring





**Figure 281.** P-79001C, Torque Sensor, Impact Damage

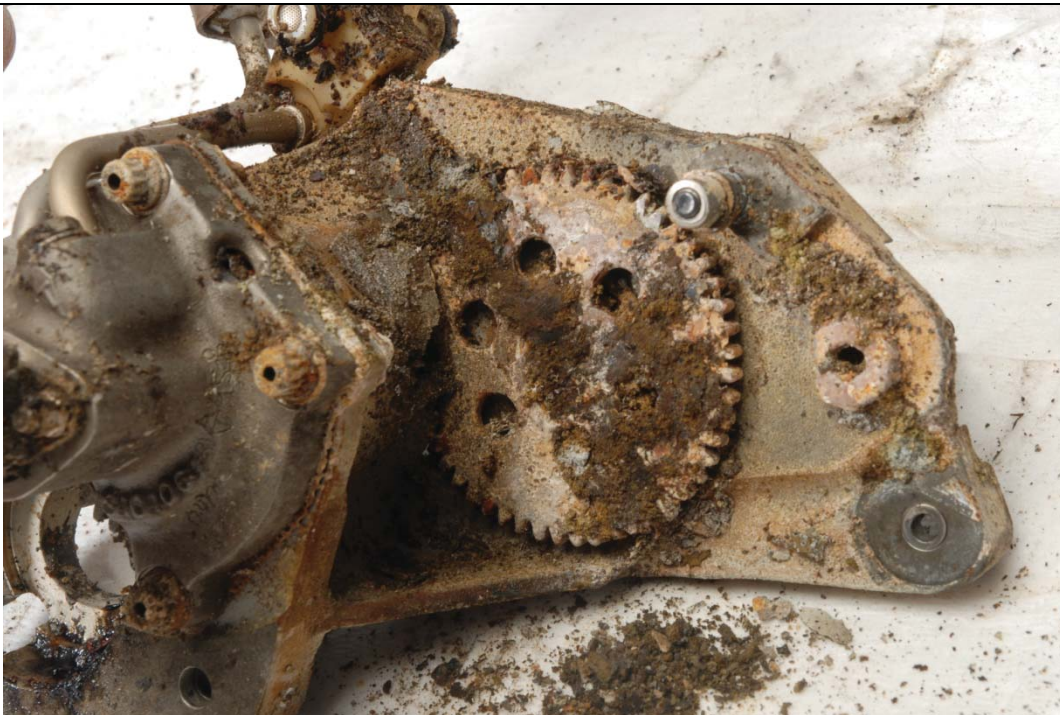


**Figure 282.** P-79001C, Helical Cam Gear





**Figure 283.** P-79001C, First Direct Drive Fuel-Control (DDFC) Gear Assembly



**Figure 284.** P-79001C, Second DDFC Gear Assembly, ALF





**Figure 285.** P-79001C, Second DDFC Gear Assembly, FLA



**Figure 286.** P-79001C, Third DDFC Gear

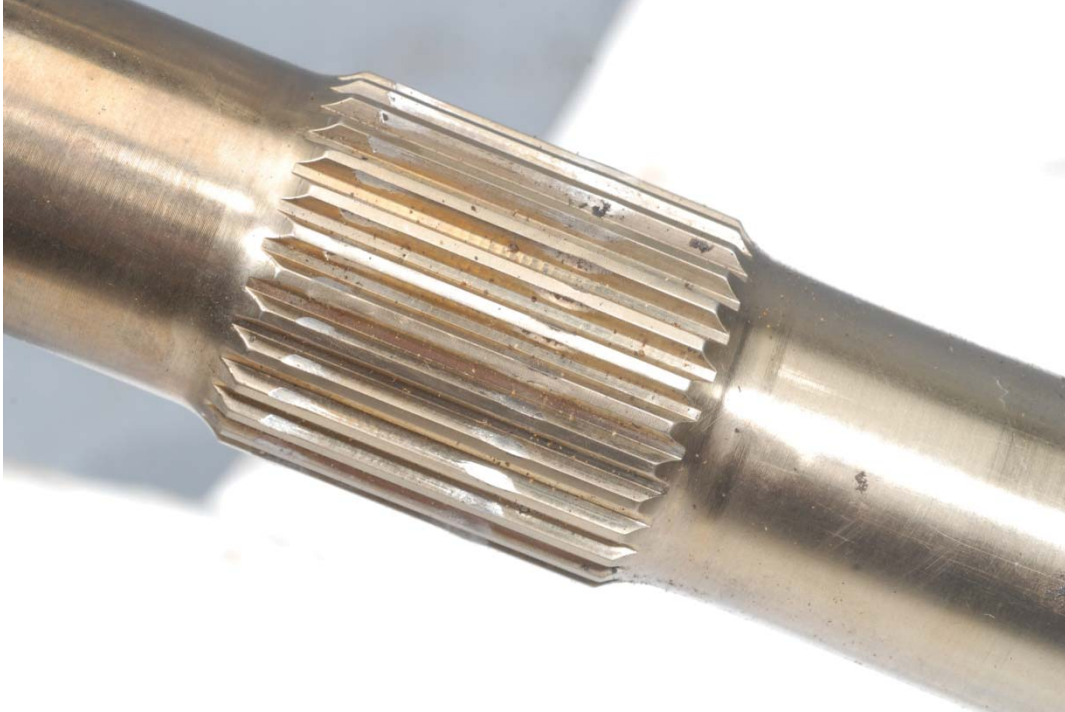


**Figure 287.** P-79001C, 4<sup>th</sup> DDFC Gear and Tach Drive Gear



**Figure 288.** P-79001C, Shouldered (Main) Shaft and First-Stage Compressor Impeller





**Figure 289.** P-79001C, Shouldered (Main) Shaft, Spline Damage



**Figure 290.** P-79001C, Torsion Shaft



**Figure 291.** P-79001C, Torsion Shaft, Shear Fracture



**Figure 292.** P-79001C, First-Stage Compressor Impeller Shroud, ALF



**Figure 293.** P-79001C, First-Stage Compressor Impeller Shroud, ALF



**Figure 294.** P-79001C, First-Stage Compressor Impeller Shroud, Rub Marks





**Figure 295.** P-79001C, First-Stage Compressor Impeller, FLA



**Figure 296.** P-79001C, First-Stage Compressor Impeller, ALF



**Figure 297.** P-79001C, First-Stage Compressor Impeller, Leading Edge Blade Damage



**Figure 298.** P-79001C, First-Stage Compressor Impeller, Rotational Scoring



**Figure 299.** P-79001C, First-Stage Compressor Impeller, Rotational Scoring



**Figure 300.** P-79001C, First-Stage Compressor Impeller, Blade Leading Edge Bending





**Figure 301.** P-79001C, First-Stage Compressor Impeller, Aft Hub Rotational Scoring and Curvic Damage



**Figure 302.** P-79001C, First-Stage Compressor Diffuser, FLA



**Figure 303.** P-79001C, First-Stage Compressor Diffuser, ALF



**Figure 304.** P-79001C, First-Stage Compressor Diffuser, Vane Leading Edge Damage



**Figure 305.** P-79001C, First-Stage Compressor Diffuser, Rotational Scoring



**Figure 306.** P-79001C, First-Stage Compressor Diffuser, Impact Damage





**Figure 307.** P-79001C, First-Stage Compressor Diffuser, Stud Fractures



**Figure 308.** P-79001C, First-Stage Compressor Diffuser, Mount Flange Fracture



**Figure 309.** P-79001C, Second-Stage Compressor Housing, FLA



**Figure 310.** P-79001C, Second-Stage Compressor Housing, ALF



**Figure 311.** P-79001C, Second-Stage Compressor Housing, Axial Compression Damage

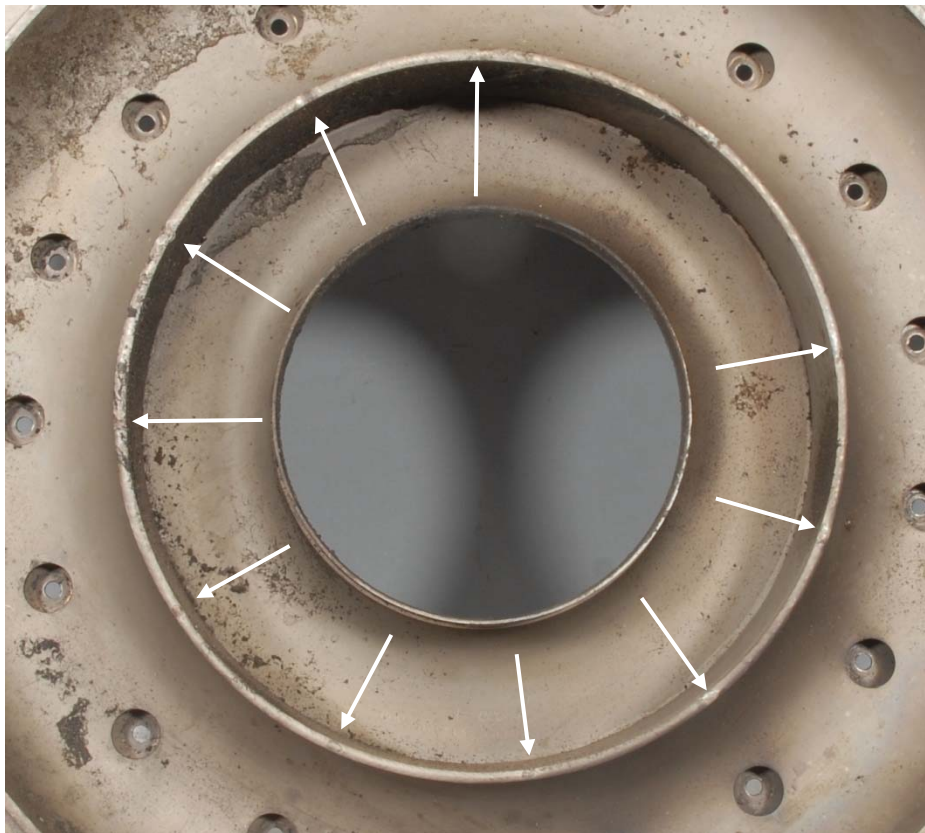


**Figure 312.** P-79001C, Second-Stage Compressor Housing, Earthen Debris





**Figure 313.** P-79001C, Second-Stage Compressor Housing, Shroud Rub



**Figure 314.** P-79001C, Second-Stage Compressor Housing, Witness Marks



**Figure 315.** P-79001C, Second-Stage Compressor Impeller, FLA



**Figure 316.** P-79001C, Second-Stage Compressor Impeller, ALF



**Figure 317.** P-79001C, Second-Stage Compressor Impeller, Shroud Line Edge Rotational Scoring



**Figure 318.** P-79001C, Second-Stage Compressor Impeller, Forward Hub and Curvic Damage





**Figure 319.** P-79001C, Second-Stage Compressor Impeller, Aft Curvic Damage



**Figure 320.** P-79001C, Second-Stage Compressor Diffuser Vane Assembly and Outer Transition Liner



**Figure 321.** P-79001C Second-Stage Compressor Diffuser Vane Assembly, Earthen Debris



**Figure 322.** P-79001C, Combustor Plenum Case and Combustor Chamber, ALF



**Figure 323.** P-79001C, Combustor Plenum Case and Combustor Chamber, FLA



**Figure 324.** P-79001C, Combustor Plenum Case





**Figure 325.** P-79001C, Combustor Plenum Case, Impact Damage



**Figure 326.** P-79001C, De-swirl Vane Assembly



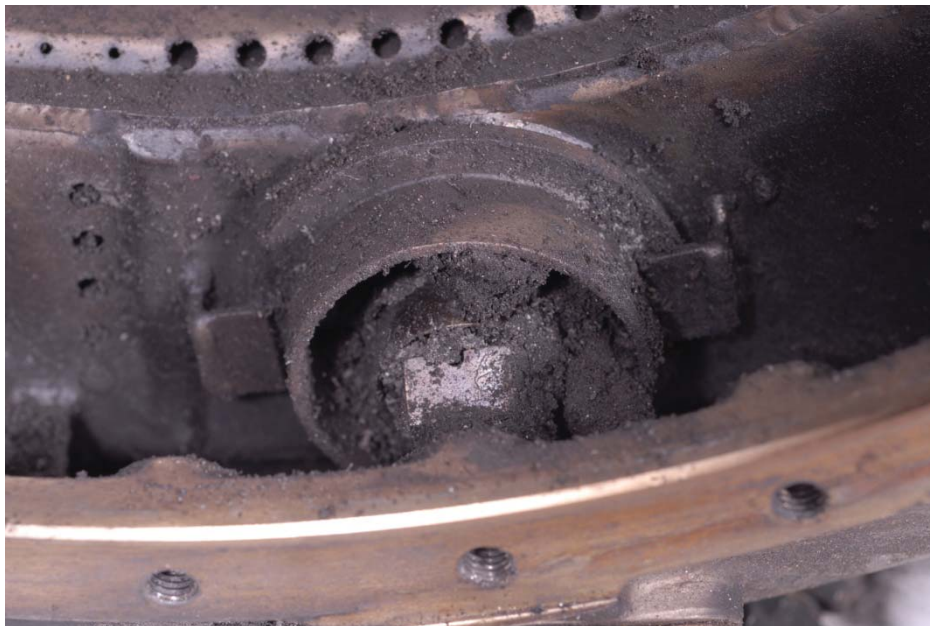
**Figure 327.** P-79001C, De-swirl Vane Assembly, Earthen Debris



**Figure 328.** P-79001C, Combustor Chamber, Impact Damage



**Figure 329.** P-79001C, Combustion Chamber, Earthen Debris



**Figure 330.** P-79001C, Combustion Chamber, Earthen Debris





**Figure 331.** P-79001C, Outer Transition Liner, Earthen Debris



**Figure 332.** P-79001C, Outer Transition Liner, Impact Damage



**Figure 333.** P-79001C, Center Curvic Coupling



**Figure 334.** P-79001C, Center Curvic Coupling, Forward Curvic



**Figure 335.** P-79001C, Center Curvic Coupling, AFT Curvic



**Figure 336.** P-79001C, First-Stage Turbine Stator Assembly, FLA





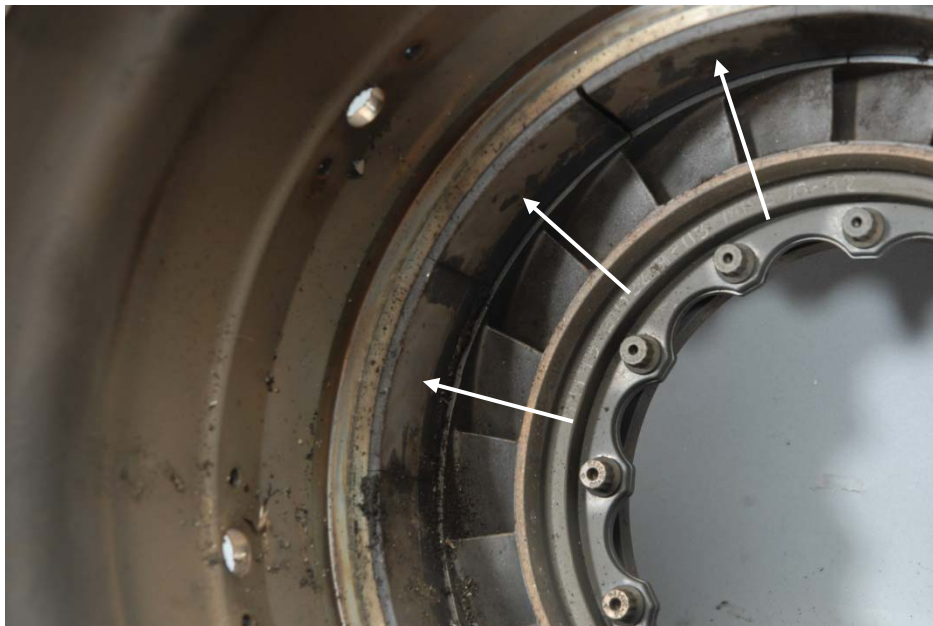
**Figure 337.** P-79001C, First-Stage Turbine Stator Assembly, ALF



**Figure 338.** P-79001C, First-Stage Turbine Stator Assembly, Earthen Debris and Metal Spray Deposits



**Figure 339.** P-79001C, First-Stage Turbine Stator Assembly, Earthen Debris



**Figure 340.** P-79001C, First-Stage Turbine Stator Assembly, Shroud Rubs



**Figure 341.** P-79001C, First-Stage Turbine Rotor, FLA



**Figure 342.** P-79001C, First-Stage Turbine Rotor, ALF





**Figure 343.** P-79001C, First-Stage Turbine Rotor, Blade Tip Rotational Scoring



**Figure 344.** P-79001C, First-Stage Turbine Rotor, Rotational Scoring



**Figure 345.** P-79001C, First-Stage Turbine Rotor, Metal Spray Deposits



**Figure 346.** P-79001C, First-Stage Turbine Rotor, Leading Edge Erosion



**Figure 347.** P-79001C, Second-Stage Turbine Stator, FLA



**Figure 348.** P-79001C, Second-Stage Turbine Stator, ALF





**Figure 349.** P-79001C, Second-Stage Turbine Stator, Metal Spray Deposits



**Figure 350.** P-79001C, Second-Stage Turbine Stator, Metal Spray Deposits



**Figure 351.** P-79001C, Second-Stage Turbine Stator, Rotational Scoring



**Figure 352.** P-79001C, Second-Stage Turbine Stator, Shroud Rub



**Figure 353.** P-79001C, Second-Stage Turbine Rotor, FLA

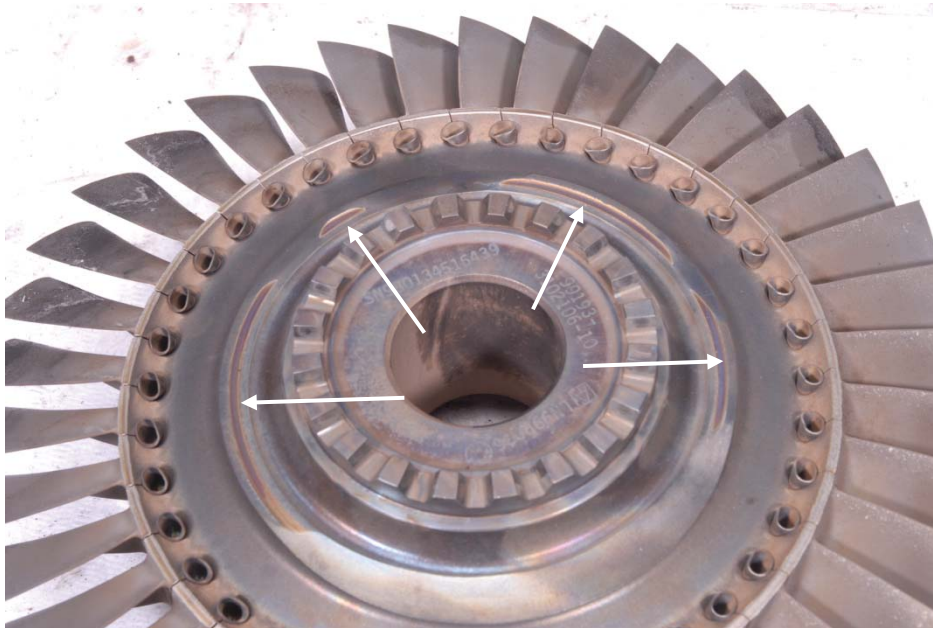


**Figure 354.** P-79001C, Second-Stage Turbine Rotor, ALF





**Figure 355.** P-79001C, Second-Stage Turbine Rotor, Rotational Scoring



**Figure 356.** P-79001C, Second-Stage Turbine Rotor, Rotational Scoring



**Figure 357.** P-79001C, Second-Stage Turbine Rotor, Metal Spray Deposits



**Figure 358.** P-79001C, Second-Stage Turbine Rotor, Metal Spray Deposits



**Figure 359.** P-79001C, Third-Stage Turbine Stator, FLA



**Figure 360.** P-79001C, Sun Gear, Third-Stage Turbine Stator, ALF





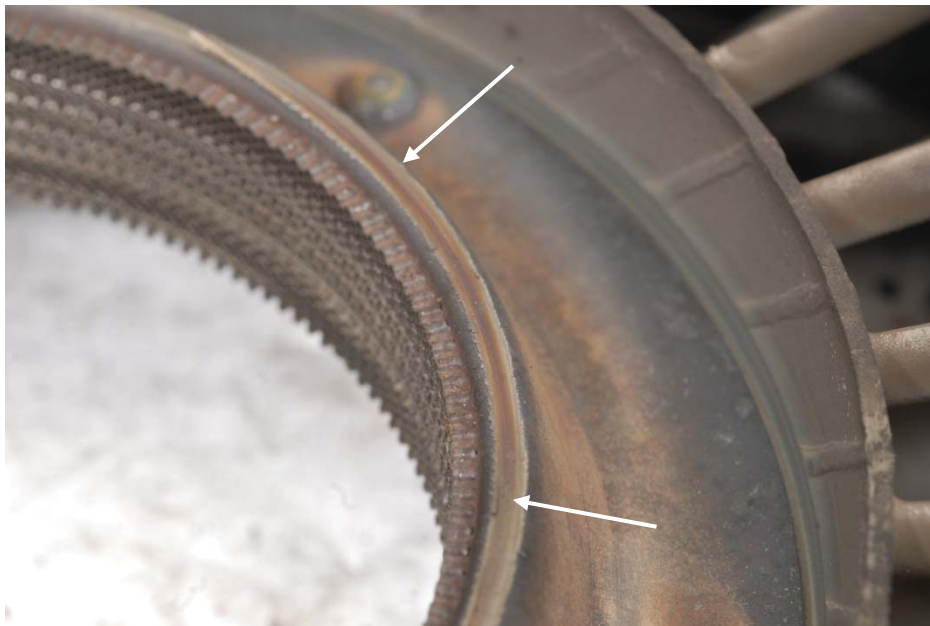
**Figure 361.** P-79001C, Third-Stage Turbine Stator, Metal Spray Deposits



**Figure 362.** P-79001C, Third-Stage Turbine Stator, Metal Spray Deposits



**Figure 363.** P-79001C, Third-Stage Turbine Stator, Rotational Scoring



**Figure 364.** P-79001C, Third-Stage Turbine Stator, Rotational Scoring

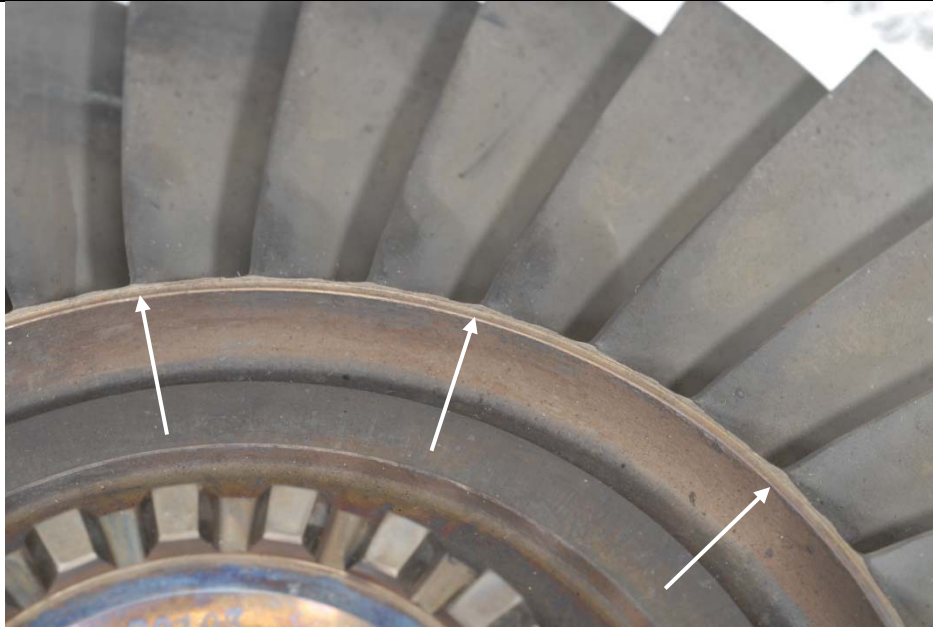


**Figure 365. P-79001C, Third-Stage Turbine Rotor, FLA**



**Figure 366. P-79001C, Third-Stage Turbine Rotor, ALF**





**Figure 367.** P-79001C, Third-Stage Turbine Rotor, Rotational Scoring



**Figure 368.** P-79001C, Third-Stage Turbine Rotor, Metal Spray Deposits



**Figure 369.** P-79001C, Rear Curvic Coupling, FLA



**Figure 370.** P-79001C, Rear Curvic Coupling, ALF



**Figure 371.** P-79001C, Engine Exhaust Duct and Thermocouple Harness Assembly



**Figure 372.** P-79001C, Engine Exhaust Duct and Thermocouple Harness Assembly

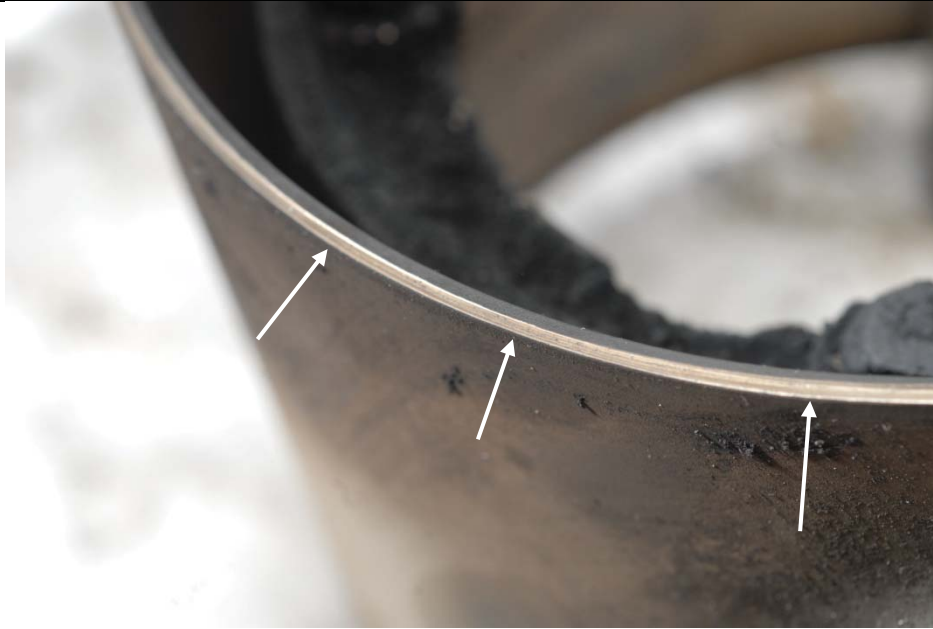




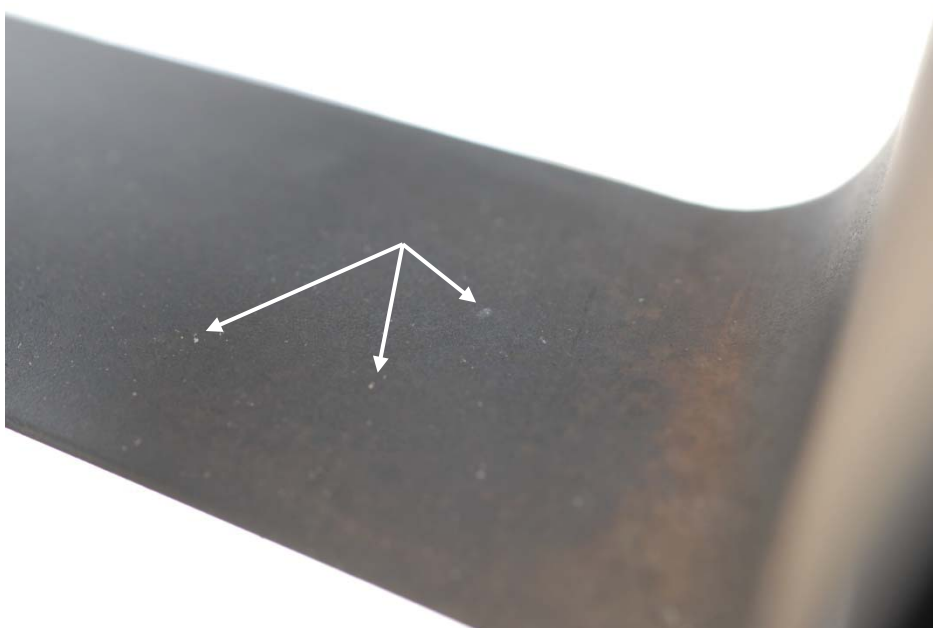
**Figure 373.** P-79001C, Turbine Bearing Support Housing, FLA



**Figure 374.** P-79001C, Turbine Bearing Support Housing, ALF



**Figure 375.** P-79001C, Turbine Bearing Support Housing, Rotational Scoring



**Figure 376.** P-79001C, Turbine Bearing Support Housing, Metal Spray Deposits



**Figure 377.** P-79001C, Turbine Oil-Scavenge Pump and Drive Shaft, FLA

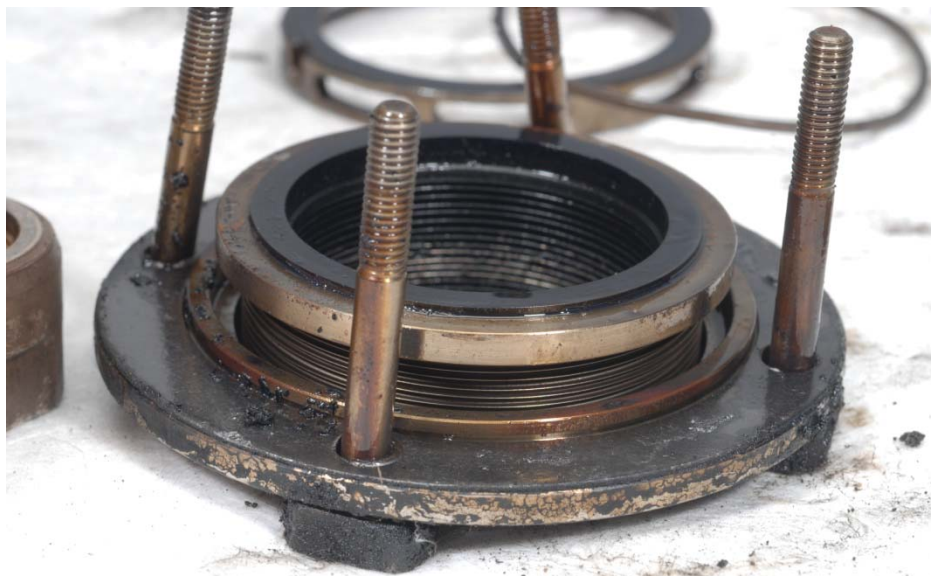


**Figure 378.** P-79001C, Turbine Oil-Scavenge Pump and Drive Shaft, ALF





**Figure 379.** P-79001C, Turbine Oil Inlet Tube



**Figure 380.** P-79001C, Turbine Air/Oil Carbon Seal



**Figure 381.** P-79001C, Turbine Air/Oil Carbon Seal



**Figure 382.** P-79001C, Turbine Bearing



**Figure 383.** P-79001C, Turbine Bearing



**Figure 384.** P-79001C, Aft (turbine) Main-Shaft Nut

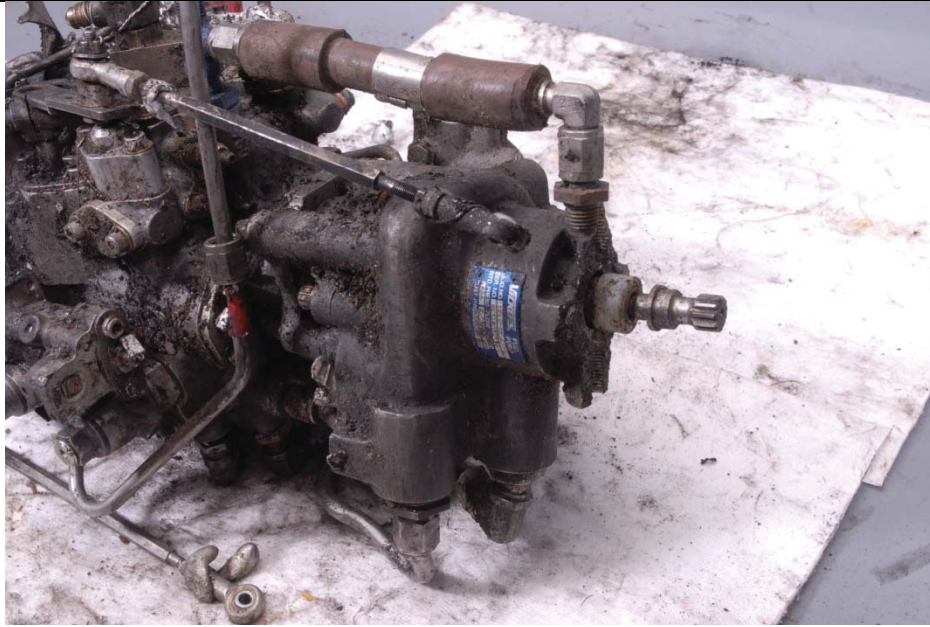




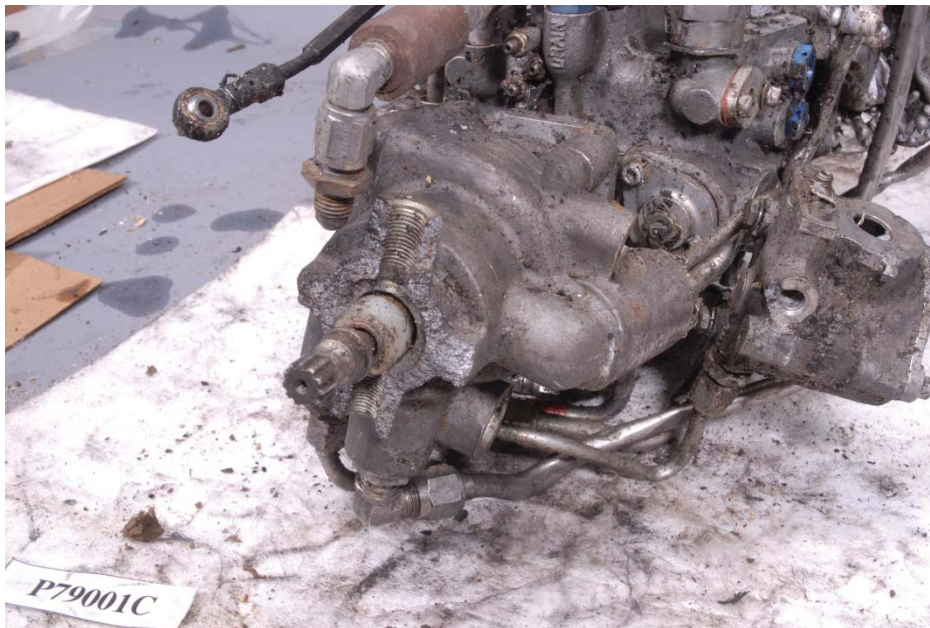
**Figure 385.** P-79001C, Manual Fuel Shutoff Valve



**Figure 386.** P-79001C, Manual Fuel Shutoff Valve



**Figure 387.** P-79001C, Fuel Pump Assembly

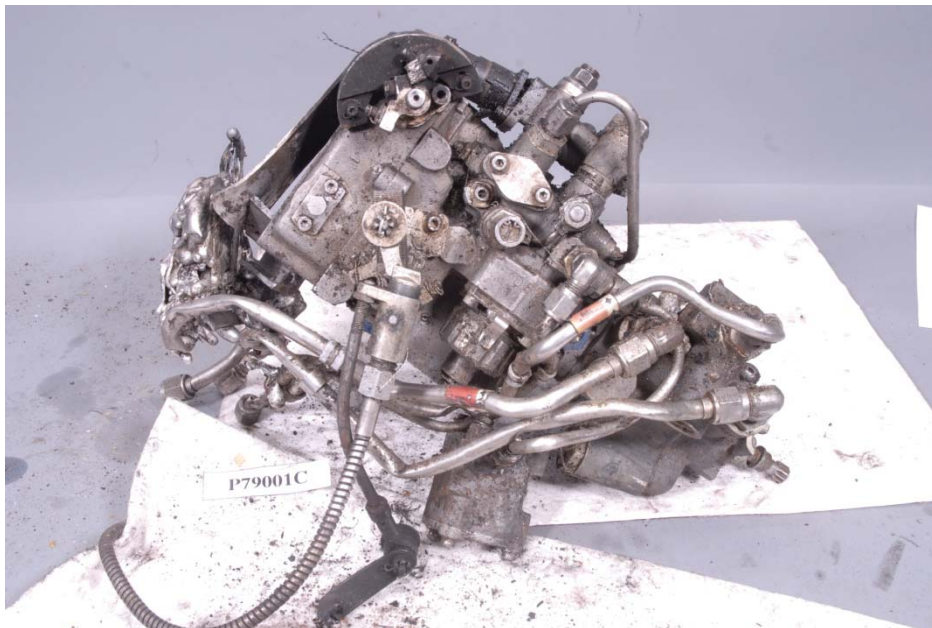


**Figure 388.** P-79001C, Fuel Pump Assembly



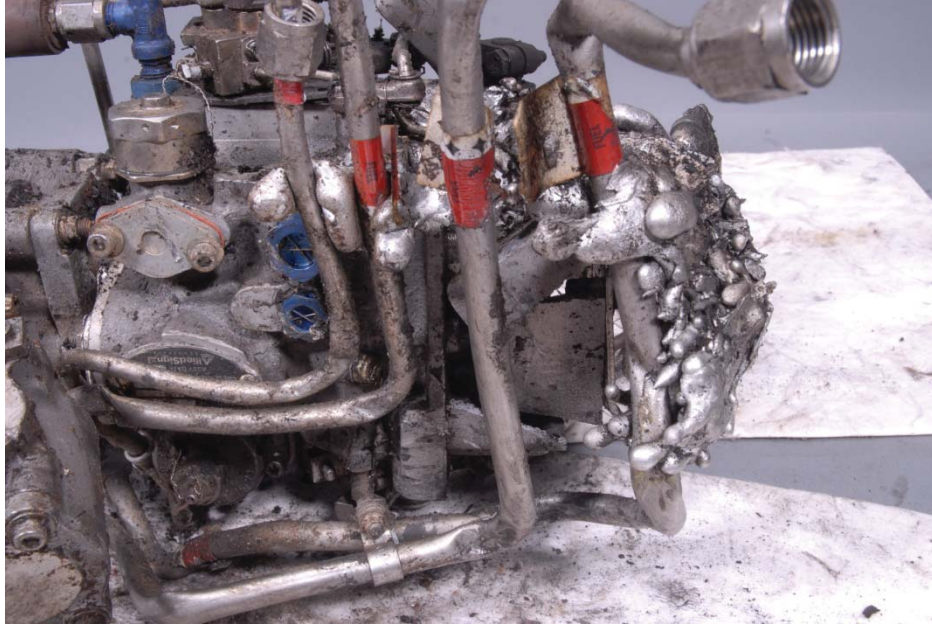


**Figure 389.** P-79001C, Fuel Pump Assembly and Fuel Control Interface



**Figure 390.** P-79001C, Fuel Control





**Figure 391. P-79001C, Fuel Control**



**Figure 392. P-79001C, Fuel Control, Impact Damage**



**Figure 393.** P-79001C, Fuel Filter



**Figure 394.** P-79001C, Fuel Filter





**Figure 395. P-79001C, Fuel Flow Divider**



**Figure 396. P-79001C, Fuel Flow Divider**





**Figure 397.** P-79001C, Fuel Manifold Hose Assembly



**Figure 398.** P-79001C, Fuel Manifold Hose Assembly



**Figure 399.** P-79001C, Propeller Governor



**Figure 400.** P-79001C, Propeller Governor





**Figure 401.** P-79001C, Propeller Governor, Fire Damage



**Figure 402.** P-79001C, Propeller Pitch Control





**Figure 403. P-79001C Propeller Pitch Control**



**Figure 404. P-79001C, Propeller Pitch Control**



**Figure 405. P-79001C, Oil Filter**



**Figure 406. P-79001C, Oil Tank**



**Figure 407.** P-79001C, Oil Tank

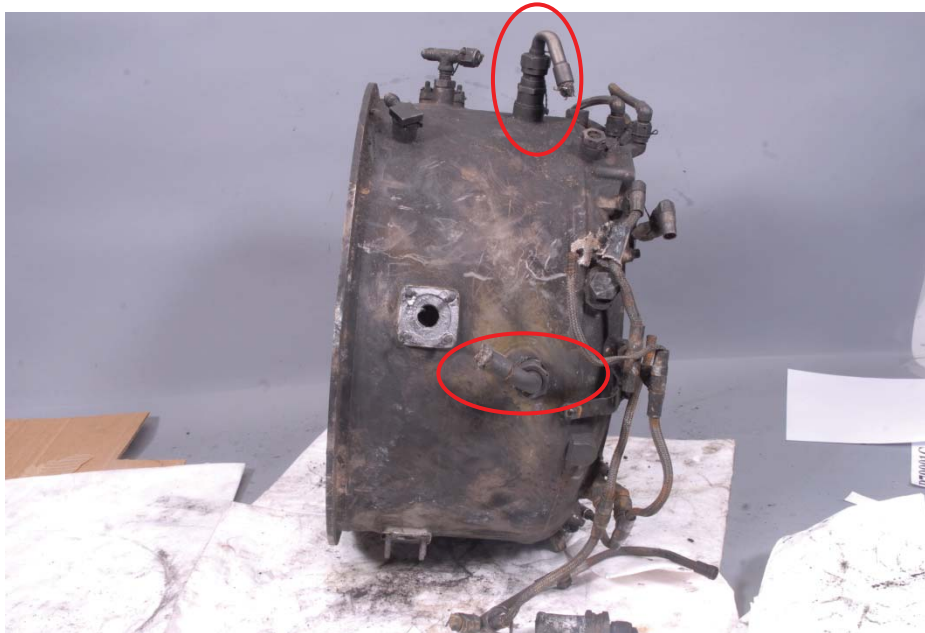


**Figure 408.** P-79001C, Ignition Exciter





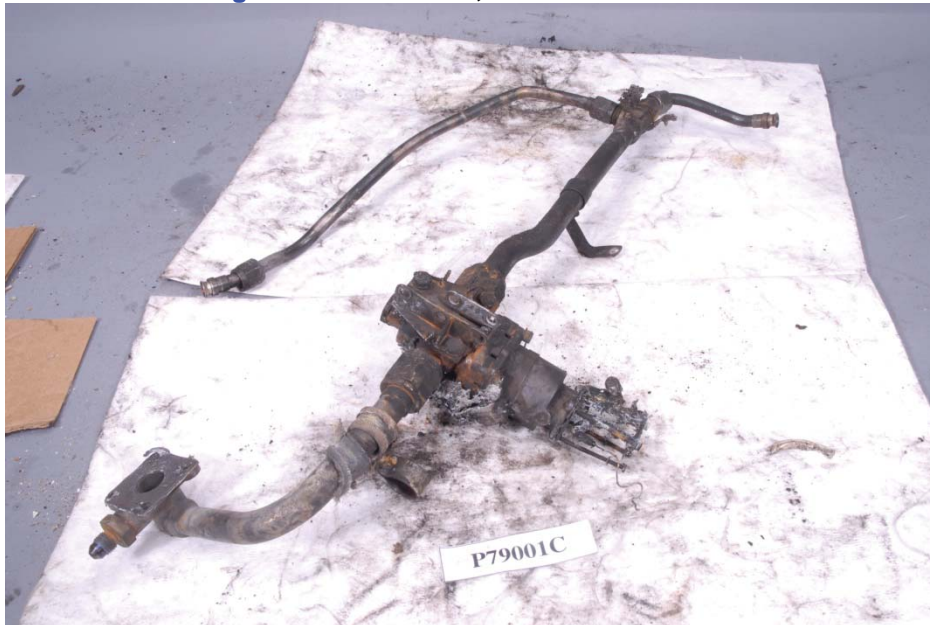
**Figure 409.** P-79001C, Exciter to Igniter Lead Assembly



**Figure 410.** P-79001C, Igniters



**Figure 411. P-79001C, Oil to Fuel Heater**



**Figure 412. P-79001C, Anti-Ice Valve**





**Figure 413. P-79001C, Feather Valve**

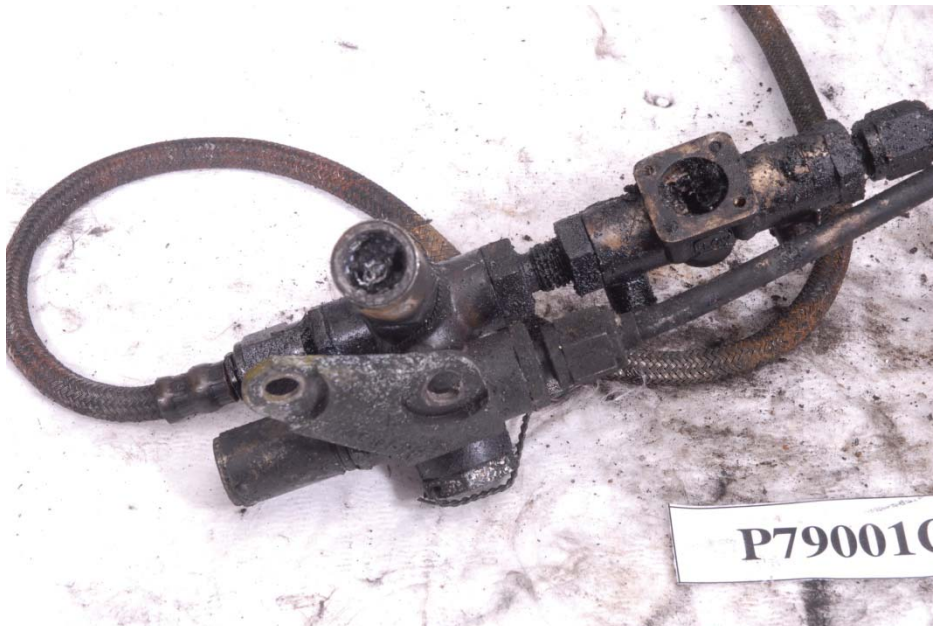


**Figure 414. P-79001C, Feather Valve**





**Figure 415.** P-79001C, P2T2 Inlet Sensor



**Figure 416.** P-79001C, Beta and Negative Torque Sensing (NTS) Switch Manifold



**Figure 417.** P-79001C, Torq/Temp Limiter (TTL) By-Pass Valve